

Wungong Catchment Environment and Water Management Project

Water Corporation

**Advice of the Environmental Protection Authority to the Minister for the
Environment under Section 16 of the *Environmental Protection Act 1986***

**(This is not an assessment of the Environmental Protection Authority under Part IV of the
Environmental Protection Act 1986)**

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1. Introduction

This report provides the advice and recommendations of the Environmental Protection Authority (EPA) to the Minister for the Environment on the EPA's review of the Water Corporation's (the Corporation's) Wungong Catchment Environment and Water Management Project (the project) under Section 16 (e) and (j) of the *Environmental Protection Act 1986* (the EP Act).

The Wungong project has been developed as an experimental trial to increase stream flow into the Wungong reservoir by undertaking silvicultural treatments in selected parts of the Wungong catchment. Specifically this relates to the removal or culling of selected trees (thinning) in dense native jarrah regrowth forest and in rehabilitated bauxite mined areas, and by harvesting exotic plantations to assist in the recovery of additional water. The operation of the trial project will be limited to the Wungong catchment for a period of 12 years and is predicted to yield 4 to 6 gigalitres of water a year into the Wungong reservoir which provides a source of water supply for the Integrated Water Supply Scheme. This expected yield represents 25 per cent of the average stream flow into the reservoir.

Thinning to reduce the density of trees in regrowth jarrah forest is expected to increase water yield as there are fewer trees to use the available water. In describing the forest as regrowth forest, it is meant that the forest has been previously logged on one or more occasions and has now regenerated to dense stands of even aged young jarrah trees. No old growth forest will be disturbed as part of this project.

The potential use of established silvicultural practices such as forest thinning to produce an increase in water yield has been reviewed and discussed in a number of previous planning studies including the report on *Forest Management to Increase Water Yield from the Northern Jarrah Forest* (WAWA, 1987) and *Perth's Water Future* (WAWA, 1995). With the observed and predicted impact of climate change on water resources in the south west, there has been a more recent focus on examining the potential for applying silvicultural practices at a catchment scale, with the recent State Water Strategy highlighting that up to an additional 40 gigalitres of water a year, over 10 years, could be generated from additional surface water runoff from existing catchments (this is assuming most water catchments in the high rainfall zone are available for catchment management activities to enhance water yield). A recommendation of the State Water Strategy was to '*support the development of improved catchment management activities and undertake a research trial to investigate the impact of active catchment management strategies that enhance water quality and quantity outcomes*'. The development of the Wungong trial project is designed to respond to this recommendation.

Projects such as the Wungong project were also foreshadowed in the current Forest Management Plan 2004-2013 (FMP), where Action 21.3 of the FMP sets out that *the Department of Conservation and Land Management (CALM) and the Forest Products Commission, in consultation with the Conservation Commission (CC) will evaluate with the Water Corporation and the Water and Rivers Commission (now the Department of Environment (DoE)) any proposal seeking to employ silvicultural treatments to increase the flow of water to surface and groundwater reservoirs*. The FMP sets out the manner in which the forest of the south west of Western Australia (within the Swan, South West and Warren regions of CALM) will be managed in an ecologically sustainable manner and has a focus on the management of State forest and timber reserves because it is primarily on these lands that

disturbance activities are permitted. As the majority of the project occurs on State forest land, the Corporation has developed the trial project including the silvicultural and management aspects of the project in consultation with the CC (as the vesting agency) and CALM (as the land manager), to be consistent with the current FMP.

Further background to the development of the project is provided in Section 2, a summary of the overall Wungong project is provided in Section 3 and a discussion of the key issues associated with the project is provided in Section 4.

2. Background

The EPA was advised of the project in 2003 where the Corporation advised that the project was consistent with the FMP and indicated its preference for the EPA to provide publicly available environmental advice on the project by way of Section 16 of the *Environmental Protection Act 1986*. The EPA agreed to this approach of providing environmental advice subject to the Corporation undertaking community consultation, including a period of public review, and the EPA receiving further technical information and confirmatory advice from the CC and CALM on whether the Wungong project is consistent with the FMP.

Since that time the Corporation has been seeking input from its stakeholders to assist in the development of the project and more recently, published a report titled 'Wungong Catchment Environment and Water Management Project' (Water Corporation, 2005a) (hereafter referred to as the 'project document') to describe the details of the project and its potential environmental effects. The project document was the basis for the Corporation's 8 week public review period (from 26 April to 22 June 2005) where submissions from stakeholders and the community were received. An additional report was also prepared which summarises the consultation undertaken to date and provides the Corporation's responses to the issues raised in the submissions (Water Corporation, 2005b). These reports can be obtained from the compact disc that accompanies this report or downloaded from Water Corporation's internet website at www.watercorporation.com.au/wungong/.

The Corporation and the EPA have also received advice from the CC and CALM to confirm that the project is consistent with the FMP. The CC's and CALM's advice on the Wungong project is provided in Appendix 2 of this report.

Following the receipt of advice from CC and CALM and the Corporation's consultation and public review process, the EPA has prepared this report to provide its advice on the environmental matters associated with the project. The scope of advice in this report does not include catchment thinning activities in other catchment areas as identified in the State Water Strategy.

The EPA's advice and recommendations contained in this report are provided under Section 16 (e) and (j) of the EP Act which enables the EPA '*to advise the Minister on environmental matters generally and on any matter which he may refer to it for advice, including the environmental protection aspects of any proposal or scheme, and on the evaluation of information relating thereto*' and '*to publish reports on environmental matters generally*', respectively. It should be noted that this report does not constitute a formal assessment under Part IV of the EP Act and does not lead to the setting of legally binding environmental conditions for the project.

In its consideration of the Wungong project trial, the EPA notes that the project implementation will be subject to an approvals process administered by CALM and that the proposed activities would be audited by the CC in accordance with the FMP. The setting of legally binding conditions on the Corporation through Part IV of the EP Act is therefore unnecessary in view of the controls available through CALM and CC to ensure the project is implemented in manner consistent with the objectives and actions in the FMP.

3. The project

The Wungong catchment is a gazetted public drinking water catchment area which supplies water to the Corporation's Integrated Water Supply Scheme and is located approximately 40 kilometres south-east of Perth. The catchment comprises an area of 12 845 hectares that has been disturbed by historical and current land uses including farming, exotic plantations, bauxite mining, and commercial logging. Dieback spread within the catchment has also had impacts on the values of the forest.

The Wungong trial project is described in detail in Section 1.2 of the Corporation's project document with the details of the proposed prescriptions in Section 5.

The on-ground activities associated with the project include:

- the thinning of dense native regrowth jarrah forest, with a focus on non-commercial thinning (up to 5100 hectares could be available for thinning). In describing the forest as regrowth forest, it is meant that the forest has been previously logged on one or more occasions and has now regenerated to dense stands of even aged young jarrah trees with basal areas greater than 30 m² per hectare;
- the thinning of trees in bauxite mined areas which were rehabilitated with native species (up to 1400 hectares). Thinning these areas will not occur until the Mining and Management Program Liaison Group (MMPLG), through CALM, release Alcoa World Alumina Australia from ongoing liability for the rehabilitation. The EPA understands that this is in the process of occurring for certain areas in the catchment;
- the gradual conversion of exotic trees to native species in bauxite mined areas that were rehabilitated using exotic species (up to 2100 hectares);
- the potential conversion of 300 hectares of pine plantations to native trees and species. This component of the project is subject to further consultation with the Forest Products Commission; and
- implementation of a range of environmental management projects in the catchment. These projects may include: control of foxes, feral bees and pigs; fauna and flora recovery plans; weed control; and installation of nesting boxes.

Through the project it is expected that the total area to receive treatments would cover approximately 62 per cent (7900 hectares) of the catchment, including about 5100 hectares of native regrowth forest and 2800 hectares of areas containing bauxite mining rehabilitation and exotic plantations. The remaining 38 per cent of the catchment will not receive any

silvicultural treatments as these areas are included in the system of formal and informal reserves or designated as experimental control sites.

As there is general acceptance of the Corporation's commitment to gradually convert areas planted with exotics trees to native species and given the proposed thinning of mined areas rehabilitated with native species will not occur until the MMPLG, through CALM, release Alcoa World Alumina Australia from rehabilitation requirements, the EPA's advice on the Wungong project is focused on the component of the project that includes thinning in native jarrah regrowth forest. This component of the project is briefly described below.

In areas containing dense stands of jarrah trees, it is proposed to undertake thinning to a target basal area of 15-18 m² per hectare to be staged over the first 4-6 years of the project. Basal area is the cross-sectional area of trees in a particular plot measured at chest height. In achieving the target basal areas, the Corporation has advised that only small trees will be selected for culling with the more mature and larger trees retained. The proposed thinning would effectively reduce the regrowth forest density from nearly 1000 stems per hectare to approximately 300-350 stems per hectare, and increase the spacing for retained trees from 3 to 4 metres to about 5 to 6 metres apart.

Individual trees will be killed by injecting the herbicide Roundup into the stems of trees or by cut stump method which involves felling the tree and applying herbicide to the stump. The cut stump method will be the preferred method for areas along burn boundaries, walk trails, recreational sites and major travel routes. These operations will be undertaken on foot with access being provided by light vehicles, utilising existing tracks.

Previous thinning studies have shown that without ongoing treatments following the initial thinning, enhanced water yields would be transient with flows returning to pre-thinning rates within ten years. To maintain enhanced water yield, the Corporation proposes to undertake follow-up treatments by way of coppice control and the control of young *Banksia* and *Allocasurina* (Sheoak) which may regenerate as dense groves in response to a more open canopy. This would occur by the application of herbicides and prescribed burning. The Corporation has advised that the key components of the understorey such as balgas, snotty-gobble and mature banksias and sheoak will be retained, according to the requirements of the jarrah silvicultural guidelines.

To maintain improved water yield beyond the duration of the trial and encourage fewer but larger trees, the Corporation has indicated that it would be desirable for further thinning of the over storey to occur in 15-20 years time and potentially again at longer time intervals depending on the forest structure. It should be noted however, that further thinning beyond the 12 year trial period would only occur in the Wungong catchment if the outcomes of the trial are supported by the project stakeholders including the CC and CALM, and is provided for in the next FMP.

4. Key Issues

As the most contentious aspect of the project relates to thinning in native jarrah regrowth forest and noting that this would occur in a high proportion of the Wungong catchment, the EPA's advice in the report is focused on this component of the project. The EPA considers that the key issues associated with this component of the project are in relation to the potential

impacts of the project on biodiversity elements of the native forest, research needs, potential water quality impacts, adaptive management, and the implementation aspects of the project.

4.1 Biodiversity issues and research needs

A consistent theme that was reflected in the submissions on the project document has been the preference for the native regrowth jarrah forest in the Wungong catchment to be left untreated to avoid impacts on biodiversity values of the forest, with some submissions suggesting that provided sufficient time, regrowth jarrah forest could eventually 'self-thin'. From the submissions it is apparent that there are some concerns over the potential impacts of the proposed thinning in the native jarrah forest on biodiversity elements of the forest such as the understorey and fauna.

In its response, the Corporation confirmed that thinning is an important component of the Wungong project if projected water yields are to be realised and further highlighted that thinning is routinely undertaken in State forests for wood production purposes in accordance with the jarrah silvicultural guidelines. The Corporation also reiterated its position that under a drying climate, thinning regrowth forests can deliver benefits to the environment in a number of areas (described further below).

Impacts on biodiversity

Although there is limited information available on the environmental impacts of forest thinning, the EPA considers there is potential for adverse environmental impacts to occur from the following areas:

- pressures on the jarrah forest ecosystem in addition to pressures from current and historical land uses and forestry practices in the Wungong catchment;
- impacts resulting from accelerating natural forest thinning processes;
- impacts from the application of herbicides. In rehabilitated areas there are potential impacts associated with ripping and scrub rolling; and
- potential loss of ecological communities reliant on the environmental conditions provided by the existing regrowth forest structure.

In general terms, the EPA notes that the biodiversity values of the native jarrah forest will be protected through the implementation of the informal reserve system and fauna habitat zones as established in the current FMP. The system of informal reserves along streams, and around diverse ecotype zones and fauna habitat zones focuses on the protection of particularly important habitat areas. Figure 18 in the Corporation's project document provides an indication of how the informal reserve system and fauna habitat zones would apply to this project.

Within the areas of native forest that are available for thinning, guidelines such as the jarrah silviculture guideline define a number of strategies to ensure that the fauna and habitat values of the forest are protected and impacts are minimised during periods of disturbance. This relates to matters such as the retention of habitat trees and key understorey species, and the implementation of measures to manage impacts of operation on soil, water and dieback spread. The EPA, in its assessment of the FMP (EPA Bulletin 1113), supported the FMP's initiatives to improve the protection of fauna values within State forests and timber reserves by developing new and revising existing forest management guidelines.

As the land manager of State forest, CALM is responsible for ensuring that the objectives, actions and guidelines provided for in the FMP will be adhered to during the implementation of the Wungong project. This will occur through CALM's routine approvals process for granting access and on-ground works on State forest lands.

Notwithstanding the system of informal reserves and the controls available through CALM, the EPA expects that where adverse environmental impacts are detected and observed through research and monitoring, the Corporation will undertake modifications to the project and specifically, the silvicultural treatments. This is further discussed in Section 4.4 (Adaptive management) of the report.

Potential environmental benefits

In addition to designing the project to be consistent with the current FMP, the Corporation has put forward the proposition that through catchment thinning, the project has the potential to deliver environmental benefits to the Wungong catchment in a number of areas. The potential environmental benefits can be summarised as follows:

Potential benefits to aquatic biodiversity – forest thinning will increase, and under certain rainfall scenarios, maintain streamflow in forest streams. The Corporation has advised that this would provide benefits to the aquatic biodiversity of forest streams by providing more water during a drying climate.

Potential benefits to forest health under a drying climate – the Corporation contends that leaving regrowth forest unthinned under a drying climate is unlikely to be the best option for the health of the forest as dense regrowth forest with reduced access to water is likely to become stressed, more susceptible to disease and parasites, and may collapse. The Corporation therefore believes that maintaining a moderate stand density by way of thinning will improve the capacity of retained trees to withstand a drying climate. While the Corporation has advised that this prediction is based on recent observations and studies in relation to forest health (Batini (2005a), Bradshaw, J. (2005), Farr et al. (2004), Landsberg (1990)), it is noted that limited work has been undertaken in the area of forest health and climate change and further research is required.

Moving a regrowth forest towards an old growth forest structure - catchment thinning could improve the regrowth forest by moving its structure closer to that of a mature forest by increasing the growth of retained trees and the spacing between retained trees. As a result, potential habitat trees would reach a size suitable for producing habitat hollows much earlier (Abbot and Whitford (2002), Whitford (2002)). The Corporation has also indicated in its project document that '*the current pole stand structure of the jarrah regrowth forest is expected to remain unchanged for several centuries unless release from competition is achieved through selective removal of excess stems to allow the forest to trend towards the characteristics of a mature forest*' (Stoneman et al. (1989) cited in Water Corporation 2005a).

It is apparent from the project document and the Corporation's response to submissions that considerable emphasis has been placed on the potential for the project to deliver benefits to the environment as described above. While the above predictions are plausible, it is noted that limited information has been provided in the project document to substantiate these predictions. The EPA has therefore taken a cautionary approach to these predictions and

particularly the notion of 'improving the forest' through thinning. In view of the observed and projected decrease in reservoir inflows, an experimental trial which includes research and monitoring to elucidate the potential environmental benefits is considered to be appropriate.

Based on a precautionary approach, the EPA emphasises the need for the proposed monitoring and research to focus on confirming the predicted environmental impacts from this trial project and for results of this work to be made publicly available. The results of research and monitoring in relation to the predicted environmental impacts will assist the Corporation and the relevant project stakeholders in determining the environmental costs and benefits of the project and whether catchment thinning for water production should be applied more widely to other catchment areas.

Project research needs

While the use of thinning to increase stream flow is well validated in research, there is limited information available in relation to the ecological effects of thinning, particularly on the scale, duration and frequency that is proposed as part of the Wungong project. For example, in its advice on the project, the CC highlighted that the impacts of more frequent disturbances on biodiversity elements (such as reptiles and fungi) are unclear.

The Corporation has acknowledged the uncertainties of the project and committed to undertaking and funding appropriate research and monitoring programs in a number of areas to gain a better understanding of the effects of thinning and to build on the existing knowledge in relation to the impact of silvicultural practices on biodiversity. With respect to monitoring, the Corporation has agreed to undertake biological monitoring, including monitoring based on CALM's ForestCheck system and integrated with groundwater monitoring, as recommended by the CC.

It is noted that research proposed as part of this project would be progressed through a technical reference group to include various Government agencies, universities and research organisations such as the CSIRO. As such, the *Monitoring and Research* section of the project document (Section 5.6.3) is very broad in scope with limited information on research projects and priorities for research and monitoring.

From the issues and questions raised during the consultation to date, there appears to be a need for research to focus on the proposed silvicultural prescriptions and management practices and their impacts on biodiversity elements of the forest such as the understorey, fungi, fauna and also fire and dieback risk and how they relate to modified forest structure and water regime. The research will also need to focus on testing the predicted environmental benefits of the project.

In summary the EPA:

- **considers that information to be collected from this project trial, through research and monitoring, along with information from untreated control catchments should aim to confirm the predicted environmental impacts of this project. It is recommended that this information be made available to the community, relevant stakeholders and Government agencies and be available for peer review; and**
- **recommends that, in developing research proposals in consultation with the relevant agencies and research organisations, priority be given to research proposals which**

address the ecological uncertainties of undertaking thinning in the manner proposed for the Wungong project. It is also recommended that in developing the research proposals consideration be given to the concerns and questions raised in submissions during the public review period.

The EPA considers that the information to be obtained from research and monitoring for this trial will assist the Corporation and the relevant stakeholders in determining whether future projects for catchment thinning for water should proceed. The information will also contribute to the development of policies and guidelines for catchment thinning for water if the practice is to be applied more widely to other catchment areas.

4.2 Water quality impacts

A number of submissions on the project document expressed concern that the project has the potential to affect the water quality of streams in the Wungong catchment and reservoir itself. Some submissions were concerned about the potential for the project to cause salinity in the Wungong catchment.

The major cause of increased salinity levels in catchments is broad scale clearing of native vegetation in high salt risk areas, particularly where there is a combination of high salt storage and high groundwater levels. In the case of the Wungong project, it is proposed to undertake thinning rather than broad scale clear felling of native vegetation. Furthermore, the catchment is largely located in a high rainfall zone (greater than 1100 mm annual rainfall zone, based on 30 years to 1980) where there are likely to be low soil salt storages in the landscape. Experimental studies have shown that logging and forest thinning in the high rainfall zone result in only temporary increases in stream salinity and stream sediments, and that annual stream salinity generally remained below 200 mg/L TDS (Bari and Ruprecht, 2003). In view of the above it is unlikely that salinity will be an issue for this project.

Other submissions expressed concern in relation to the potential for the project to affect the drinking water quality of the Wungong catchment which is a public drinking water source area. Submissions focused on the use of chemicals to kill trees and highlighted the risk of erosion and turbidity in streams from silvicultural activities.

Project activities which may pose a risk to the water quality of streams and the Wungong reservoir include the thinning in native jarrah regrowth forest and bauxite rehabilitation areas, and the harvesting of plantations. The major risks associated with these activities include turbidity and pathogen contamination from people in close proximity to the reservoir and, to a lesser extent, hydrocarbon contamination from vehicles and machinery.

In broad terms, the protection of water quality will be achieved by ensuring that activities are not undertaken in vegetated buffers along stream zones, and around the reservoir, and through the implementation of best practice management measures. In practical terms this includes the implementation of the management strategies provided in the DoE's draft Wungong Drinking Water Source Protection Plan (DoE, 2005), appropriate pesticide application practices (i.e. consistent with the DoE's Statewide Policy No. 2 *Pesticide Use in Public Drinking Water Source Areas*) and appropriate supervision of contractors in areas proposed to receive silvicultural treatments. The commitment to maintain a 100 metre buffer from the top water level of the water reservoir has also been recognised and on site supervision will be required to ensure these buffers are adhered to in the field.

It is understood that there are opportunities for the development of a retrospective study which would utilise the monitoring and operations proposed for the Wungong project to examine the effectiveness of stream buffers on water quality. For example, the DoE has advised that the relative change in water quality parameters pre and post thinning will provide data for use in advising policy and guidelines for clearing controls around reservoirs and their feeder streams. The use of water quality monitoring from the Wungong project to assist in the development of future policy and guidelines is supported. It is noted that the DoE will continue to liaise and work with the Corporation on this matter and specifically on the issue of further refining the existing water quality monitoring program for the Wungong project to ensure water quality results provide a meaningful indication of the impacts of the project on water quality, and to determine whether corrective action/modified prescriptions are required in subsequent stages of the project.

It is recommended that the Corporation continues to work with the Water Source Protection Branch of the DoE prior to and during the implementation of the project with respect to:

- **the standard and level of water quality monitoring proposed to occur prior to, during and following on ground works; and**
- **the management strategies and practices to be undertaken in the catchment, particularly in the area designated as the Reservoir Protection Zone,**

to ensure that the water protection strategies in the draft Plan (and its revisions and updates) and its water quality objectives are being achieved.

4.3 Implementation aspects of the Wungong project

While the Corporation project document contained sufficient information to enable the community and stakeholders to provide informed views and submissions on the project, it is noted that considerable detail on the implementation of the project is yet to be developed. As such, both CALM and the Corporation have identified the need for an interagency agreement that defines the responsibilities and process to ensure the implementation of the project is undertaken in a manner that meets, the statutory and policy requirements of the agencies involved.

It is also understood that a project management plan may be prepared by the Corporation to manage the implementation of the project. Due to the level of public interest and the complexity of the project, the EPA recommends that a more formal Project Implementation Management Plan (PIMP) be prepared by the Corporation prior to or during the early stages of the project's implementation. The recommended PIMP should consolidate information from a number of areas of the project and clearly describe how the various commitments in the project document will be fulfilled. The PIMP should be in a form that can be accessed by the community and stakeholders, and be updated regularly as new information about the project becomes available.

It is recommended that the following matters to be included in the PIMP:

- information on research proposals and environmental projects - specifically how they will be further scoped, funded and implemented etc;
- the development of the interagency structure and process as recommended by CALM; and
- a consultation strategy.

At an operational scale the following matters may be included:

- project objectives and key performance indicators;
- schedules and timelines for staged on-ground implementation;
- collection of baseline ecological data;
- monitoring proposals, including for example: an expanded water quality monitoring program which incorporates the advice of the DoE; and biodiversity monitoring, including some based on the ForestCheck system and integrated with groundwater monitoring, as advised by CC;
- demonstration of how adaptive management will occur at an operational scale. For example, information on how decisions on the implementation of the project will be guided by the results and outcomes of ongoing monitoring and research; and
- information on reviews and audits.

In addition to CALM's role in ensuring that the project is undertaken in a manner consistent with the FMP, it is noted that CC would conduct audits of the activities in accordance with the FMP. The recommended PIMP could provide a basis for such audits.

With respect to reporting, it is also recommended that the Corporation's first project review (proposed to occur every 4 years) be brought forward and be submitted to the CC in 2008. This would enable the Corporation's first project review to be incorporated with the CC's mid term audit performance report on the implementation of the FMP, which under the Ministerial Conditions for the FMP (Condition 2-2 of Ministerial Statement 641), is required to be submitted by 31 December 2008. This is followed by the EPA undertaking a review of CC's audit findings and the preparation of a publicly available report to the Minister for the Environment on CC's compliance with the Conditions.

4.4 Adaptive management

In the context of adaptive management, the EPA considers that it will be important for the project to include a capacity to vary thinning prescriptions and target basal areas during the implementation of the project. For example, variations to prescriptions and target basal areas should be undertaken by the Corporation where monitoring and research shows that environmental impacts are greater than expected. It is understood from the project document that the program of thinning will be staged over 4 to 6 years and that there will be opportunities to amend or improve prescriptions during the staged implementation of the trial. The EPA expects that further details in relation to how adaptive management will occur with respect to prescriptions and basal areas and the decision making process to support this will be developed through the technical reference group and documented in the PIMP.

In addition to applying adaptive management at an operational scale, the EPA also notes the advice of the CC that *"...there is very limited trialling of a range of different thinning and management prescriptions. The CC is of the view that there is an opportunity to undertake adaptive management on a more experimental basis generating more knowledge for future application although perhaps leading to a lower increase in water yield."*

For example the proposal appears to be designed to only test one thinning regime over all available areas in most of the catchment (to 15 m²/ha basal area) against a control area in a small sub-catchment. The testing of a range of thinning options would be appropriate in a properly designed adaptive management trial."

The EPA agrees that there needs to be further consideration to testing a range of thinning options in the context of an experimental trial, and notes from the Corporation's project document that this would be possible in native regrowth forest and rehabilitated bauxite mined areas. It is expected that the CC's recommendations will be given effect through the interagency working group process and documented in the PIMP.

5. Conclusions

At a time when declining rainfall is being experienced across much of the south west, the reductions in stream flow from forest catchments are significant. Recent work by the DoE and others on the Stirling Dam Catchment predicts that a further 11 per cent decline in rainfall over the next thirty years could likely result in a further 31 per cent reduction in annual water yield (Berti et al. 2004). The predicted reductions in rainfall and stream flow poses a number of significant issues for management of water demand, supply and environmental management.

The Corporation believes that this trial project is necessary to test the overall hypothesis that thinning regrowth forest in water catchment areas can provide environment and water benefits under a drying climate. Specifically, the Corporation believes that thinning in catchment areas is an adaptive management response needed to increase or maintain streamflows and environmental values in riverine environments under the influence of a drying climate.

What the outcomes of project trial will mean for the future management of water catchments under a drying climate will be important. The EPA considers there is merit in undertaking an experimental trial to determine whether silvicultural treatments can be applied for water production purposes without having adverse impacts on forest ecosystems and water quality.

The EPA has received advice from CALM and CC which confirms that the activities proposed as part of this project trial are consistent with the objectives and actions in the current FMP. It is noted that CALM, as the land managers for State forests will administer an approvals process for the Corporation to ensure that the project is implemented in manner consistent with the FMP, and that the CC will undertake audits of the activities. In view of the controls available to manage the project, the EPA's advice and recommendations in this report are focused on the research needs, water quality monitoring, implementation issues, reporting and adaptive management aspects of the project.

Of importance is the need for the research and monitoring from this project to demonstrate that catchment thinning, at a scale and frequency proposed for water production purposes, can

be undertaken in manner which does not adversely effect forest ecosystems and has potential to provide benefits to the environment. This information will assist in the consideration of whether future projects for catchment thinning for water should proceed and would also contribute to the development of policies and guidelines if catchment thinning for water is to be applied more widely to other catchment areas.

Taking into account the above, the EPA advises that the Wungong project should proceed as an experimental trial subject to the Corporation implementing the EPA's advice and recommendations provided in this report and summarised in Section 6.

6. Summary of Recommendations

The EPA submits the following recommendations to the Minister for the Environment:

1. That the Minister notes that this report provides the EPA's advice and recommendations on its review of the Corporation's Wungong trial project under Section 16 (e) and (j) of the *Environmental Protection Act 1986*.
2. That the Minister notes that the CC and CALM have provided advice to confirm that the Wungong project is consistent with the objectives and actions in the current Forest Management Plan 2004-2013.
3. That the Minister notes that the EPA provides the following advice and recommendations to the Water Corporation:
 - a. *Research needs* – The information to be collected from this project, through research and monitoring, along with information from untreated control catchments should aim to confirm the predicted environmental benefits of this project. It is also recommended that in developing research proposals in consultation with the relevant agencies and research organisations, priority be given to research proposals which address the ecological uncertainties of undertaking thinning in the manner proposed for the Wungong project. It is also recommended that in developing the research proposals consideration be given to the concerns and questions raised in submissions during the public review of the Corporation's project document. The information from monitoring and research should be made available to the community, relevant stakeholders and Government agencies and be subject to peer review.
 - b. *Outcomes of Research* - The EPA expects that the information to be obtained from research and monitoring will assist in the consideration of whether future projects for catchment thinning for water production should proceed and would also contribute to the development of policies and guidelines if catchment thinning for water is to be applied more widely to other catchment areas.
 - c. *Water quality* - It is recommended that the Corporation continues to work with the Water Source Protection Branch of the DoE prior to and during the implementation of the project with respect to:
 - the standard and level of water quality monitoring proposed to occur prior to, during and following on ground works; and
 - the management strategies and practices to be undertaken in the catchment, particularly in the area designated as the Reservoir Protection Zone,

to ensure that the water protection strategies in the draft Plan (and its revisions and updates) and its water quality objectives are being achieved.

- d. *Reporting* - With respect to reporting, it is recommended that the Corporation's first project review (proposed to occur every 4 years) be brought forward and be submitted to the CC in 2008. This would enable the Corporation's first project review to be incorporated with the CC's mid term audit performance report on the implementation of the FMP, which under the Ministerial Conditions for the FMP (Condition 2-2 of Ministerial Statement 641), is required to be submitted by 31 December 2008. This is followed by the EPA undertaking a review of CC's audit findings and the preparation of a publicly available report to the Minister for the Environment on CC's compliance with the Conditions.
 - e. *Adaptive Management* - The EPA agrees with the CC that there needs to be further consideration to testing a range of thinning options in the context of an experimental trial, and notes from the Corporation's project document that this would be possible in native regrowth forest and rehabilitated bauxite mined areas. It is expected that the CC's recommendations will be given effect through the interagency agreement process and documented in the PIMP.
4. The Minister notes that the EPA advises that the Wungong project should proceed as an experimental trial subject to the Corporation implementing the EPA's advice and recommendations provided in this report.

Appendix 1

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Appendix 2

**Advice from the Department of Conservation and Land Management and the
Conservation Commission of Western Australia**



Conservation Commission
of Western Australia

Mr Wally Cox
Chairman
Environmental Protection Authority
GPO Box K822
PERTH WA 6842

Dear Wally

I have received the final version of the Water Corporation's Wungong Catchment Environment and Water Management proposal.

I indicated in my letter to the Water Corporation of 16 December 2004 and copied to you, that 'Once the final proposal has been reviewed, advice will be provided to the EPA that the proposal is consistent with the FMP'.

Given the short notice of the final draft, the Conservation Commission will need to review the document in more detail. However it is clear that the Water Corporation has appropriately taken into account the issues raised by the Conservation Commission. These have been particularly addressed in S 1.7.1 of the proposal and then elsewhere through the document. It is noted that the proposal includes an expansion of a technical reference group to include the Conservation Commission. The group, including the Department of Conservation and Land Management, Department of Environment, Forest Products Commission, Alcoa and the Water Corporation, has been formed to develop the proposal and review the annual works program.

The Conservation Commission would conduct audits of the activities in accordance with the Forest Management Plan.

The Conservation Commission thus advises you that the proposal is consistent with the objectives and actions of the Forest Management Plan 2004-2013. It is considered that formal assessment under the Environmental Protection Act may not be necessary, bearing in mind the extensive stakeholder group involvement leading to finalising of the proposal.

Yours sincerely

Dr John Bailey
Chairman

C. MURRAY

28 January 2004



Department of Conservation
and Land Management



Conserving the
nature of WA

Your ref:
Our ref: E001335 PJ:JA
Enquiries: Paul Jones
Phone: 9442 0335
Fax: 9389 5388
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FAXED

28.1.05

DEPARTMENT OF ENVIRONMENTAL PROTECTION RECORDS SECTION	
3 1 JAN 2005	
FILE NO	_____
NAME	_____
FILE NO	_____
NAME	_____

Dr W Cox
Chairman
Environmental Protection Authority
PO Box K822
PERTH WA 6842

Dear Wally

WATER CORPORATION WUNGONG PROPOSAL

In response to a request from Peter Moore of the Water Corporation, the Department reviewed the 16 December 2004 version of the *Wungong Catchment Environment and Water Management Proposal* and was able to advise him by letter on 7 January 2005 that the Department considered it to be consistent with the *Forest Management Plan 2004-2013* (FMP). A copy of that letter was sent to you.

The Water Corporation has now sent me the most recent version (25 January 2005) of the proposal document for review. The Department has reviewed this version and our view that the proposal conforms to the FMP is unchanged.

I understand a representative from the Department will be invited to the Environmental Protection Authority's meeting that considers the Wungong proposal. This will provide an opportunity for the Department, if necessary, to elaborate on the views set out in the letter of 7 January 2005 and answer any questions you or other members may have.

Yours sincerely

Keiran McNamara
EXECUTIVE DIRECTOR

28 January 2005

cc P Moore, General Manager, Planning & Infrastructure Division, Water Corporation
Chairman, Conservation Commission of WA

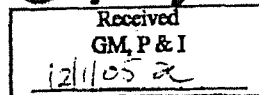
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Department of Conservation
and Land Management

COPY



Investment
nature of

Your ref: E001316
Our ref: PJ:JA
Enquiries: Paul Jones
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Mr P Moore
General Manager
Planning and Infrastructure Division
Water Corporation
PO Box 100
Leederville WA 6902

Mr. Ferguson

*Please note and
action on request.
Please draft a reply
acknowledging receipt of
this letter
12/1/05*

Dear Mr Moore

I refer to your letter of 23 December 2004, in which you requested advice from the Department of Conservation and Land Management (CALM) on the consistency of the Wungong catchment management proposal with the requirements of the Forest Management Plan 2004 -2013 (FMP).

I note that you intend to revise the document again and notwithstanding my comments below on the conformity of the proposal with the FMP, I would like to see the final document prior to it being considered by the Environmental Protection Authority.

The Department has examined the 16 December 2004 Draft of the "Wungong Catchment Environment and Water Management Proposal" which you attached and I am able to advise you that we consider the proposal is consistent with the FMP.

The basis for this view is:

1. The objective for the management of the forests for water in the FMP (page 49) includes the purpose of seeking to "....increase the flow of water to surface and groundwater reservoirs." The Wungong proposal works towards the achievement of that objective.
2. The FMP proposes (page 38) Action 16.1.2 to "develop schedules of future silvicultural treatments for stands of trees to promote growth of timber that can be used to produce sawlogs". This is to achieve the objective of "seeking to realise the productive capacity of the forests". The Wungong proposal will promote the growth of sawlog product.

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Postal address: Locked Bag 104, Bentley Delivery Centre, Bentley, Western Australia 6983

3. All proposed formal reserves, informal reserves and indicative fauna habitat zones are identified in the proposal (Figure 18) and these are excluded from timber harvesting and non-commercial thinning treatments.
4. The Wungong proposal commits (page 48, 5.5.1.4) to identifying the appropriate silvicultural objective for each stand and then apply the appropriate treatment as detailed in the current (or subsequently amended) guideline *Silvicultural Practice in the Jarrah Forest*. This commitment is relevant whether the treatment is commercial or non-commercial and will ensure the main disturbance operation of timber harvesting is carried out in accordance with the FMP.
5. The replacement of clearfelled stands of exotic trees with native species is in accordance with Action 19.1.1 of the FMP (page 46) and its supporting objective, which seeks "to develop self-sustaining ecosystems of native species from regeneration or rehabilitation operations in native forest". This is a positive aspect of the proposal in that it enhances CALM's capacity to treat such areas.
6. The FMP includes the objectives "...of seeking to provide for adaptive management to improve forest management" (page 61) and "...of seeking to generate and transfer knowledge ... with a view to leading to improvements in forest management" (page 64). The implementation of the Wungong proposal will assist in achieving those objectives.

This is relevant in that I note in his letter to you of 16 December 2004, the Chairman of the Conservation Commission suggested that thinning to residual basal areas other than those proposed should be considered in order for it to be more a trial than an operation. While the implementation of thinning to residual basal areas other than those set out in the 16 December 2004 draft would take the proposed treatment outside the recommended limits for thinning in the jarrah silvicultural guideline, the proposal would still be consistent with the FMP through the above adaptive management and knowledge objectives.

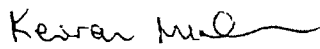
In providing advice that the Wungong proposal conforms in broad terms with the FMP, I note that there is still considerable detail on implementation that was not appropriate to include in the documentation or is to be developed over the life of the project. This includes matters such as:

- research and monitoring proposals;
- the timing and intensity of prescribed burning; and
- prescriptions for the rehabilitation of areas where exotic species are removed.

The documentation of the proposal includes a section (5.3) on liaison on implementation matters and the list of commitments made by the Water Corporation (Appendix 1) indicate where advice will be sought from CALM and other organisations with respect to management issues. However, as CALM is the responsible land manager I believe a more formal interagency structure and process are required to ensure implementation is undertaken in a manner that meets, as far as possible, the statutory and policy requirements of those involved. I would be happy to discuss this further when the EPA has considered the project.

In examining the document, I have identified some areas in the text, where clarification would improve the document and have included an attachment (4 pages) detailing these comments and suggestions.

Yours sincerely



Keiran McNamara
EXECUTIVE DIRECTOR

7 January 2005



Att.

cc Chairman, Conservation Commission
 Chairman, Environmental Protection Authority



Wungong Catchment Environment and Water Management Project

This disk contains
PDF documents and
a free reader is
available from
www.adobe.com



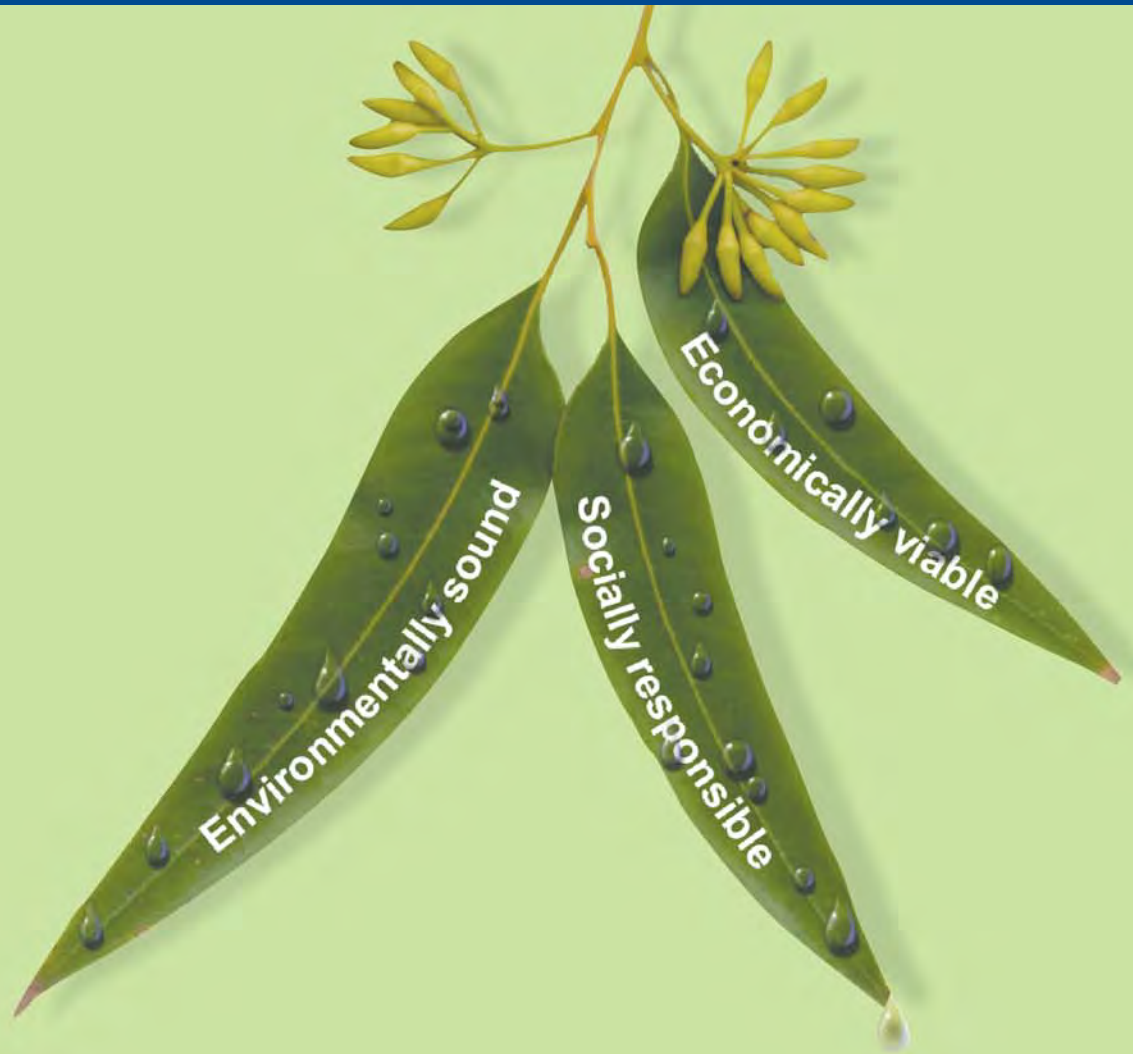
www.watercorporation.com.au/wungong

The two reports on this disk are

- Project document (March 2005)
- Response to public review (August 2005)

 **WATER**
CORPORATION
September 2005

Wungong Catchment Environment and Water Management project



*Sustainable management of water
services to make Western Australia
a great place to live and invest*

Wungong Catchment management project



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This document and other information is also available on the Water Corporation's Internet web-site at: <http://www.watercorporation.com.au/wungong/> (under 'environment and community > environmental programs > Wungong Catchment project').

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Figure i Front cover image: jarrah leaves and fruit



Foreword

The forested catchments in Western Australia are important for the environment and our community for many reasons, in particular for their role in biodiversity and for their role as a source of high quality, low cost, drinking water.

The Water Corporation has a significant investment in assets and is committed to sustainable management of water services in Western Australia with a security through diversity approach. This includes increasing re-use of treated wastewater and reducing per capita water demand. However, even with these important efficiency drives, with population growth and changes in climate, there is the need to restore water availability from existing catchments.

This document presents a project for adaptively managing the Wungong Catchment to achieve sustainable outcomes through a 12-year project, reviewed 4-yearly, to determine whether the proposed management has improved environmental and water outcomes. The Wungong Catchment is an hour's drive south-east of Perth, and has been supplying water for Perth since 1925. This catchment now provides 6% of the yield of the Integrated Water Supply Scheme (IWSS). The IWSS is a public water supply with groundwater and surface water sources, providing reliable high quality water to 1.5 million people in the Perth metropolitan area, Mandurah, Pinjarra, Harvey, some south-west towns, the Eastern Goldfields and towns and farming areas along the way to Kalgoorlie-Boulder. This project will increase the streamflow in this catchment by 25%, halfway back to the wetter period of streamflows during last century.

A technique for improving the efficiency of our existing surface water sources is by catchment thinning. This technique involves culling selected trees to reduce the forest density, in this project to a spacing of 5–6 m. Catchment thinning could also improve the regrowth forest by moving its structure closer to that of a mature forest and increasing the growth of retained trees.

Importantly potential habitat trees would reach a size suitable for producing habitat hollows much earlier if selected surrounding trees were thinned. The costs associated with this proposed forest management can be sustained from the value of the extra 4–6 gigalitres of water recovered from the catchment annually. Forests and water are part of the same system, are mutually reliant and need to be managed together.

The Water Corporation has sought the input of many stakeholders to assist with the preparation of this project over a period of two and half years. During the project, the Water Corporation will continue to openly engage with the community and peak organisations.

This project has been designed to fit within the existing framework of the State's Forest Management Plan 2004–2013. The package of management strategies and silvicultural prescriptions used in this project are allowed for under the Forest Management Plan. Other elements include staged conversion of exotic tree species to native species and an emphasis on research, monitoring, audit and public reporting as part of adaptive management.

This document sets out the commitments of the Water Corporation with respect to adaptive management of the Wungong Catchment. It also serves as the contract between the community and the Water Corporation to ensure that the commitments are achieved.

Jim Gill
Chief Executive Officer
Water Corporation

Executive Summary

Each person in the community relates to forests and catchments differently, with views that range from the practical to scientific to spiritual and emotional. This project document will therefore mean different things to different people. The Water Corporation has prepared this document to explain its Wungong Catchment management project for those that are interested in forest, water, catchment and environmental issues, and for those who will become interested.

The Wungong Catchment is a drinking water catchment an hours drive south-east of Perth in Western Australia (WA), that has supplied the community with good quality water since 1925. The catchment is a disturbed environment with a history of land-uses including logging, pine plantations, farming and mining. It has also been impacted by dieback. Currently the catchment has no farming or active mining, but as most of it is State forest it has the potential to be used for commercial timber harvesting. Forest management, which includes timber harvesting, also includes other techniques, and these can be used to improve the forest and conserve the environment. A technique which has been used in the past for forest improvement is called thinning, and is the key part of this project to improve the environment and increase streamflow. As the native trees selectively culled in the thinning as part of this project would not produce commercial grade timber, it is classified as non-commercial thinning.

In the past, and mostly before 1920, timber harvesting practices in the south-west of WA have converted much of the jarrah forest from old-growth forest to a regrowth forest. The regrowth forest is relatively even aged and uniform in structure, and often quite dense. An overstocked forest will compete for water. The jarrah is a hardy tree that will not thin itself like the karri trees further south.

The current pole-stand structure of the jarrah regrowth forest is expected to remain unchanged for several centuries unless release from competition is achieved through selective removal of excess stems to allow the forest to trend towards the characteristics of a mature forest. The Victorian catchments, compared to the south-west of WA catchments, contain mostly old-growth forest and where they have been converted to a regrowth forest, the catchment run-off (which comes from rainfall) has reduced by 50%–60%.

Trees greatly impact the catchment water balance. Evaporation and vegetation transpiration (evapo-transpiration) combined with the geometry and soils in the drinking water catchments in south-west WA, mean only 5% of rainfall ends up as run-off in the streams. This fraction varies from 2% to 19% depending on the catchment and changes with climate. Changes in land-use, in particular changes in vegetation, have a large impact on run-off.

Past experiments in the south-west of WA, within 60–100 ha catchments, have demonstrated streamflows can be increased substantially if a regrowth forest is thinned. Other experiments on forest stands demonstrate that thinning will increase the growth of the retained trees. Recent measurements, in a stand that had been previously thinned, showed no change to number and abundance of understorey flora species. Thinning a forest changes it towards a mature state, with larger more widely spaced trees. This configuration results in less evapo-transpiration per unit forest area.

Given the benefits of a mature forest with its greater diversity of forest structure, greater biodiversity and more run-off than a regrowth forest, this project plans to change the structure of the regrowth forest in selected parts of the Wungong Catchment towards that of a mature forest (Figure ii). This process would be carried out in a controlled manner with best-practice adaptive management.



This includes monitoring, research, independent auditing and ongoing consultation with the community and peak organisations. The project is designed to run for 12 years, reviewed every 4 years and is expected to cost the Water Corporation approximately \$20 million.

The thinning part of the project will be conducted over 4–6 years, with the remainder of the 12-year period used for coppice control, research and observing the catchment. There is expected to be a 25% increase in streamflow, which will benefit the aquatic and terrestrial ecosystems and the community as it improves the reliability of the Wungong Brook water source. It will restore some of the run-off lost over previous years without the need for new infrastructure.

This project may result in more frequent thinning than actually occurs for timber production but will result in increased growth rates of retained trees and increased streamflow. Monitoring and research to assess the positive and negative impacts on the various components of biodiversity is a major commitment of the Wungong Catchment management project. The new knowledge gained will support the adaptive management approach being followed in this trial.

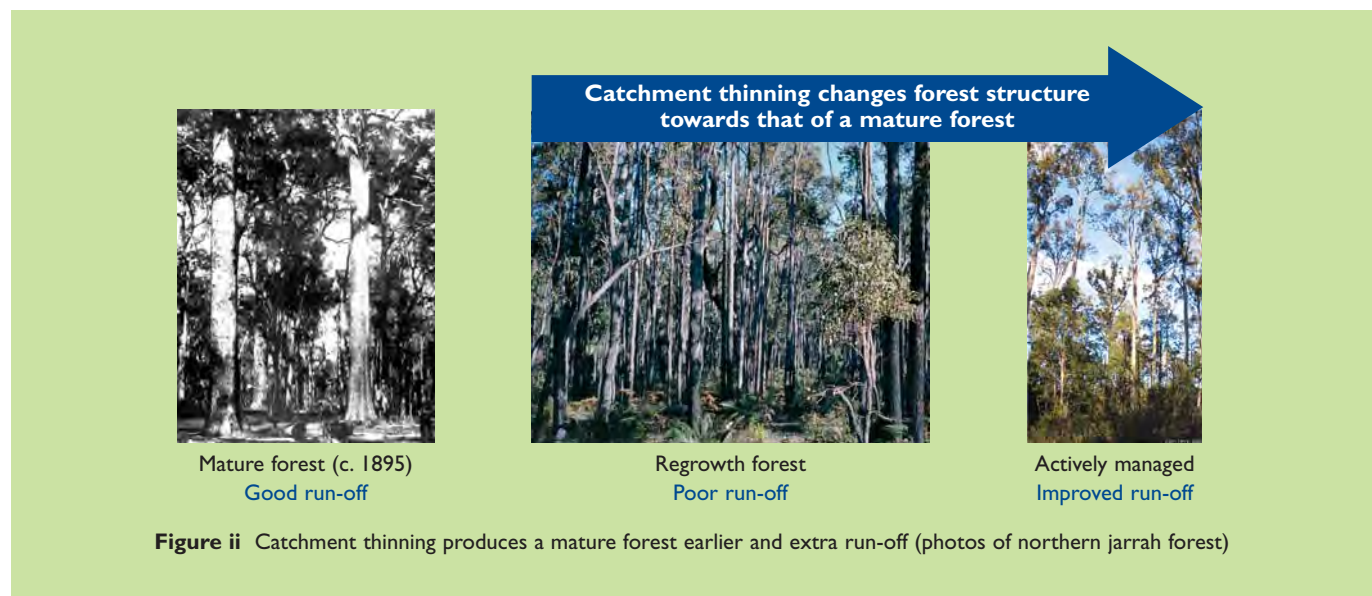
The Water Corporation, in providing sustainable management of water services for WA, has adopted a 'security through diversity' approach and has initiated a suite of projects including demand management, industrial water recycling, desalination, groundwater and surface water sources, water trading and catchment management. This approach recognises the impact of a drying climate, a steady increase in WA's population, and the importance of a range of new water sources. Importantly it also has projects under way to ensure water is used wisely.

The mandate for this Wungong project is given by the Premier's State Water Strategy that was launched in 2003. This strategy identified catchment management as a potential large water source. The strategy also identified the need to conduct a trial as part of a

staged approach that builds on a wealth of past research and water planning. This project is to undertake that trial. As the project is forest management as well as catchment management, it has been designed to be consistent with the State's peak forest management processes. It is consistent with the Conservation Commission of WA's Forest Management Plan 2004–2013, and builds on the strengths of ecologically sustainable forest management.

Catchment thinning is not a new idea, and thinning from a forest improvement perspective has been practiced for many years in the south-west of WA. As a water source, catchment thinning was recognised in a consultative process that led to the Perth's Water Future report in 1995, and more recently as part of the consultative process for the Premier's State Water Strategy in 2003. The Water Corporation has been in consultation with stakeholders for over two and half years and has formed a policy and a technical reference group to help guide the project development. The reference group includes representatives from key government and industry organisations and will continue through the project.

Wungong Catchment has an area of 12 845 ha and is a mosaic which contains more than native regrowth forest. With the past bauxite mining by Alcoa World Alumina Australia, 19% of the catchment has been cleared, mined and rehabilitated. Alcoa has been commended on its rehabilitation, which has evolved over the years. The rehabilitation before 1988 contained tree species that were not native to the local region (exotic species), and after 1988 a native jarrah forest was returned during rehabilitation. Most of the rehabilitation is quite dense following the completion criteria the government has set Alcoa, to the point the rehabilitation is currently using more water than even the regrowth forest. This project would, with agreement of Alcoa and relevant government agencies, thin the mining rehabilitation and have a staged conversion of exotic tree species to native species.



As well as the exotic tree species in the older mining rehabilitation, there is also a pine plantation making up 2% of the catchment. This has been recently harvested by the Forest Products Commission. The project's objective for this area is for it to be regenerated with native species if there is mutual agreement between the relevant parties.

The area of the Wungong Catchment proposed for active management is up to 62% of the total catchment area, although some of this will be open enough so it does not require thinning. Thirty eight per cent remains as protected areas intertwined throughout the treated area. The protected areas contain formal and informal reserves (e.g. stream buffers), reservoir buffer and experimental controls. The retained trees within the non-commercially thinned area, will be approximately 5–6 m apart or about 350–400 stems/ha.

The Water Corporation believes the catchment thinning will have a net positive effect on the environment. However, as part of good catchment management there are additional environmental projects that are proposed.

These could include declared flora and fauna recovery plans, improving weed control and helping investigate the control of feral honey-bees that compete for fauna habitat. As Wungong Dam supplies water to the community using gravity not pumping which uses energy, and because there is a balance between the release of carbon from thinning and storing of carbon from faster growing retained trees – the project is approximately greenhouse gas neutral.

Climate in the south-west of WA has changed and will continue to change. There was a step reduction in rainfall of approximately 10–15% across the south-west in 1975, which was primarily caused by natural climate variability and the enhanced greenhouse effect. This change reduced streamflows in our drinking water catchments by 50%. Then after 1996 the rainfall reduced another 8% which caused a further 30% reduction in streamflow, and into the future climate projections are for a continuing drying trend in the south-west of WA. Adaptation to a changing climate is important.



A drying climate impacts the environment as well as the water sector. Some trees in the south-west of WA, such as the tuarts and wandoo, are already showing the signs of stress that can be in part attributed to a drying climate. During 2001 there were streams that stopped flowing for the first time in recent history. Catchment thinning can be used as part of an adaptive management strategy for a changing climate, and with the monitoring and research in this project there will be knowledge developed to help guide future management.

As with any project there are potential negative impacts, but there is a sound understanding on which to base strategies to minimise the risk from these potential impacts. The project is also adaptive and will change if required to improve the management of Wungong Catchment.

The Water Corporation believe the Wungong Catchment management project is environmentally sound, socially responsible, economically viable and will be managed with good governance (Figure iii). Following the precautionary principle, if approved the project will take protective action for the environment and water in the Wungong Catchment.

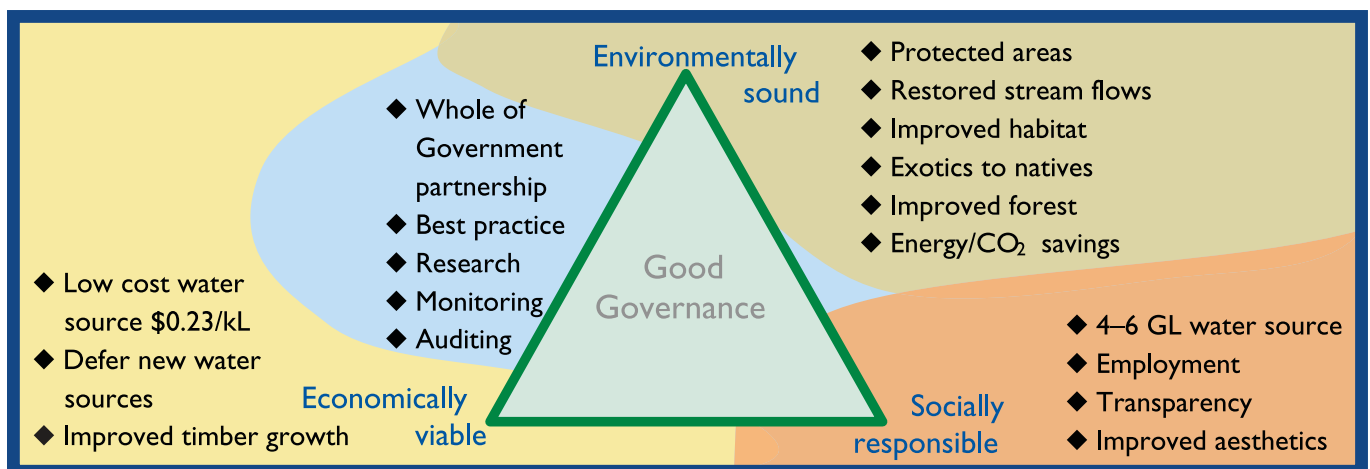


Figure iii Sustainability benefits of project

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Abbreviations

°C	degrees Celsius (unit of temperature)
AGO	Australian Greenhouse Office
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
CALM	Department of Conservation and Land Management
CAMBA	China-Australia Migratory Bird Agreements
CAMS	Confederation of Australian Motor Sports
cm	centimetre (unit of length equal to one hundredth of a metre)
CO ₂	carbon dioxide (greenhouse gas emitted in most WA electricity generation)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEP	Department of Environmental Protection (see DoE)
DEZ	Diverse Ecotype Zones
DoIR	Department of Industry and Resources
DoE	Department of Environment (joining WRC and DEP)
EIA	Environmental impact assessment
EPA	Environmental Protection Authority
FDI	Fire Danger Index
FHZ	Fauna Habitat Zones
FPC	Forest Products Commission
g/ha	grams per hectare
ha	hectare (unit of area equal to ten thousand square metres)
HRZ	High Rainfall Zone (region with long-term annual rainfall more than 1100 mm)
IOCI	Indian Ocean Climate Initiative (see web-site www.ioci.org.au)
IRZ	Intermediate rainfall zone (region with 900 mm to 1100 mm annual rainfall)
IWSS	Integrated Water Supply Scheme (servicing Perth, Mandurah, to Kalgoorlie)
JAMBA	Japan-Australia Migratory Bird Agreements
GL	gigalitre (unit of volume equal to one million kilolitres)
GL/a	gigalitres per annum (annual volume of water)
kg/ha	kilograms per hectare (unit of aerial density)
kL	kilolitre (unit of volume equal to one thousand litres or a cubic metre)
km	kilometre (unit of length equal to one thousand metres)
km ²	square kilometres (unit of area equal to one hundred hectares)
KPI	Key Performance Indicator
LAI	Leaf Area Index (ratio of leaf area on plant to ground area)
LRZ	Low rainfall zone (region with long-term annual rainfall less than 900 mm)
m	metre (unit of length)
m ²	square metre (unit of area)
m ³	cubic metre (unit of volume equivalent to a kilolitre)
mAHD	metres above Australian Height Datum (elevation reference datum)
mg/L	milligrams per litre (unit of solution concentration)
m/h	metres per hour (speed of fire used for Fire Danger Index)
mm	millimetre (unit of length equal to one thousandth of a metre)
mS/m	millisiemens per metre (unit of conductivity)
MMPLG	Mining and Management Program Liaison Group
NHMRC	National Health and Medical Research Council
r ²	linear goodness of fit correlation coefficient (1 is good fit, 0 is poor fit)
RPZ	Reservoir Protection Zone
SDI	Soil Dryness Index
t/a	tonnes per annum (annual mass)
WA	Western Australia
WAWA	Water Authority of Western Australia (from 1985-1996 after which it formed the Water Corporation and WRC)
WRC	Water and Rivers Commission (see DoE)

Note: unless mentioned otherwise, all departments are Western Australian State Government.



I Introduction

1.1 Background

Access to a reliable supply of high quality drinking water at an acceptable cost is vital for any community. Water is essential for life and impacts directly on most aspects of the human and natural world. Catchments that supply this water integrate changes in human activity and natural processes, such as rainfall. In the south-west of Western Australia (WA) catchments are usually forested, and often modified by forestry, mining and farming. They have also been subject to significant changes in climate. As an important source of water for the community, catchments need to be adaptively managed under the current drying climate for water and environmental values.

Catchments are natural systems with multiple land-uses that impact on water quality and quantity, are managed by multiple organisations often having overlapping areas of responsibility, and are surrounded by a community with a range of changing values.

In response to changes in these catchment aspects, catchments and their values have changed in the past and will continue to change into the future.

This document presents a project that considers past management of Integrated Water Supply Scheme (IWSS) surface water catchments in the light of a changing climate (Terry et al., 2004), and aims to provide a solution for their sustainable management. The IWSS is a public water supply that services one and a half million people in Perth metropolitan area, Mandurah, Pinjarra, Harvey, some south-west towns, the Eastern Goldfields and towns and farming areas along the way to Kalgoorlie-Boulder. Just over half the current demand of the IWSS is met by water supplied from groundwater, with the remainder from surface water. The IWSS surface water catchments cover approximately 4460 km² and the 16 dams that harness their flow have a current asset value of \$700 million (Figure 1).

With an increasing population, even with a reduction of water used by each person, more water sources are required now and into the future.

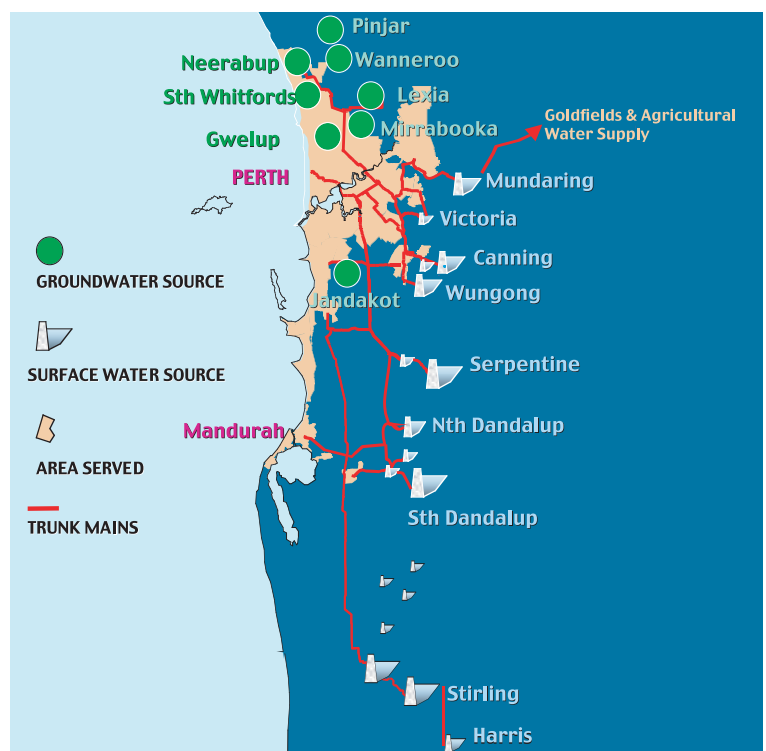


Figure 1 Integrated Water Supply Scheme surface and groundwater sources

The Western Australian Government's paper 'A State Water Strategy', released in 2003, examines several options for reducing water use and for increasing water supplies for Perth and for other users. The strategies include water conservation and efficiency measures, water re-use, the provision of new supply sources such as construction of additional dams, development of additional groundwater schemes and a desalination option, as well as resource protection and catchment management. By 2006, seawater desalination will be added to the mix of sources in response to a reduction in system capacity due to a decrease in streamflow from 1997.

The balance between water supply and customer demand is maintained by managing demand, water trading, reusing wastewater for industry and developing new water sources when required. The approach is to provide security through diversity.

New water source infrastructure options have higher capital and operating costs than current sources and most options have the potential for some impact on the environment. Water conservation and efficiency measures have more appeal and will continue to be vigorously pursued. However, as the population increases and the climate changes, additional water sources will need to be found.

One opportunity identified in the 'A State Water Strategy' is to increase water yield from existing catchments through forest management (pages 39 to 40 of the strategy). This water source would utilise existing infrastructure (dams and pipelines), would be gravity fed and therefore would not require expensive and energy-intensive pumping, and has the potential to significantly increase current yields from the existing harnessed water catchments. An overarching review by Matiske Consulting Pty Ltd for the Water Corporation in 2002 shows that there is potential to increase yields from Integrated Water Supply Scheme (IWSS) surface catchments by at least 40 GL/a (GL is a gigalitre or one million kilolitres, and a GL/a is a gigalitre per annum).

These findings are consistent with those identified by the Water Authority of Western Australia from a review conducted in 1987. An extra 40 GL represents an increase of 15% in the current annual IWSS demand (261 GL) and 13% of IWSS's unrestricted annual water demand (306 GL). The current forecast for Perth and Mandurah's annual population growth is approximately 1.7%, dropping to 1.0% by 2030 when this population will be approximately 2.2 million (medium scenario from Western Australian Planning Commission, 2000). Demand for water will follow this trend, in particular as the current restricted per person demand is similar to the expected demand under the Water Corporation's 2012 target of 155 kL/person/a.

As part of adaptive management, a staged approach is often prudent and hence a research trial is a logical step. The location for a trial should be somewhere that is representative of other areas, well understood, in need of improvement, and ideally close to the public and researchers.

As well as looking to landscape scale catchment management the 'A State Water Strategy' supported "the undertaking of a research trial to investigate the impact of active catchment management strategies that enhance water quality and quantity outcomes". This document proposes such a trial in the Wungong Catchment. The streamflow in the Wungong Catchment was 28.6 GL/a (1911–1974) and then a change in rainfall reduced the streamflow to 18.3 GL/a (1975–2003). Since 1997 the rainfall has reduced again, with streamflows in the Wungong Catchment now only 13.6 GL/a (1997–2003). The current dam in the Wungong Catchment was built in 1979, it is 65 m high with a crest length of 460 m and can store 60 GL.

The IWSS catchments from Mundaring in the north to Harris in the south are mainly in State forests and produce high quality drinking water for the community, but although protected they are disturbed environments with a range of other land-uses such as sources of timber products and bauxite mining (Figure 2).



The forest itself is also varied, although most of it is relatively evenly structured regrowth forest, compared to the more diverse old-growth forest it replaced (see Appendix 2: Forests compared).

The management of native forests throughout Australia, including Western Australia, has been a contentious issue for several decades, particularly regarding clear-felling, wood-chipping and preservation of old-growth stands. Therefore new proposals will be scrutinised by the scientific community, the conservation movement and the general community. The Water Corporation acknowledges these concerns and has actively consulted with many interest groups during the past two years and half years.

The interest groups included State Parliamentarians, Local Government, the Conservation Council of Western Australia, industry, academia and government agencies. Twenty six people attended a day long field visit to the catchment of the Wungong Dam to examine various stand conditions and to discuss the current state of knowledge and future options (list of attendees is in Appendix 3: 27 September 2002 field trip).

The consensus on the day indicated that the Water Corporation should prepare a specific project for review by the Environmental Protection Authority (EPA) and for public comment. Mattiske Consulting Pty Ltd was

then commissioned by the Water Corporation to develop a list of issues that should be addressed. Over one hundred copies of the Mattiske Report were distributed widely as a discussion paper to key stakeholders and their feedback was used to develop this project.

Throughout this document there is reference made to terms such as 'treatment', 'thinning', 'logging' and 'forestry'. Everyone has slightly different perceptions as to what these terms mean and these terms also have technical definitions that forest professionals such as Department of Conservation and Land Management (CALM) and Forest Products Commission (FPC) use. To avoid confusion as to what it is that we mean when we use these terms they are defined in the Glossary (see page 84).

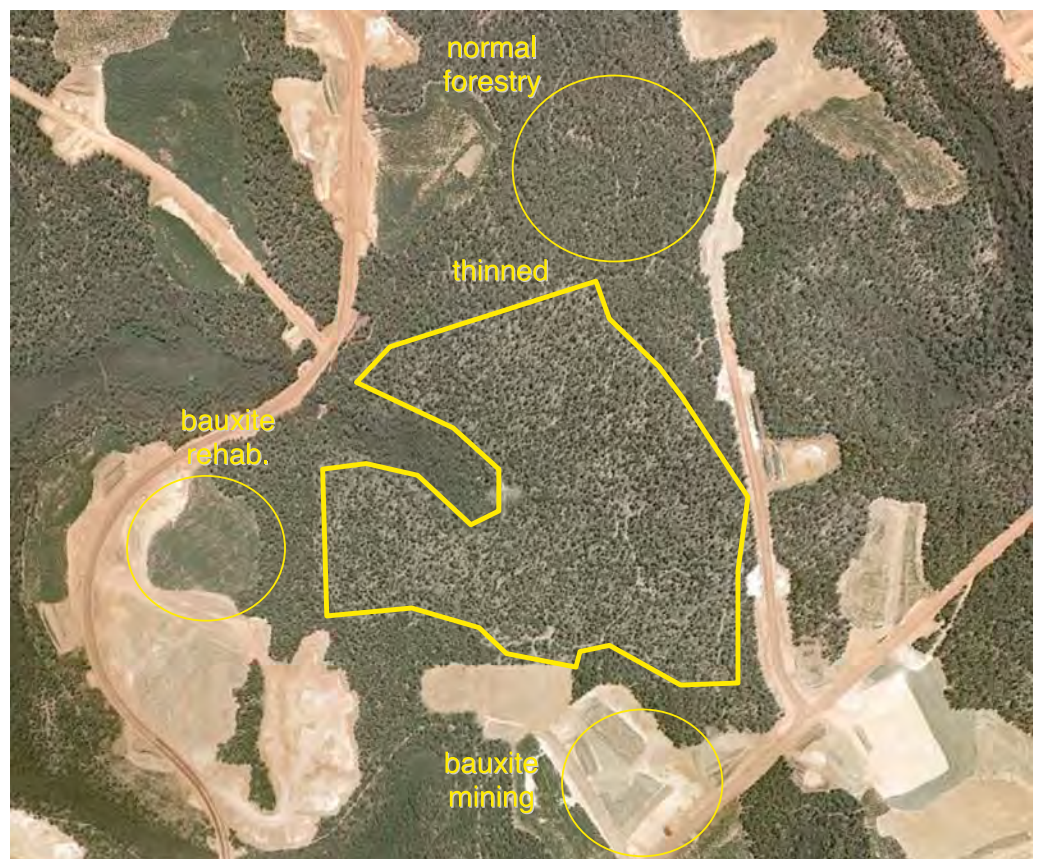


Figure 2 Catchment land-uses (January 1999 aerial photo over Higgins Catchment, Conjurunup Catchment, thinned in 1989 to 15 m²/ha)

1.2 Project

This project is for a forest management trial on the Wungong Catchment which covers an area of 12 845 ha. It is anticipated that approximately 62% be managed by thinning existing forest to a target basal area of 15–18 m²/ha and by rehabilitating selected areas of exotic species back to native species. This is a change in forest density from nearly 1000 stems/ha to approximately 300–350 stems/ha, i.e. at a spacing for retained trees of about 5 to 6 m (many more stems/ha than an old-growth forest). The Water Corporation expects an additional average of 4–6 GL/a of streamflow during this trial. There is a range of possible streamflow increases due to uncertainty of the future rainfall.

The proposed Water Corporation funded treatments would:

- ◆ designate those areas of native forest that will not be treated because they are not over-dense or are protected as informal and formal reserves under the Forest Management Plan 2004–2013, reservoir buffer and experimental controls;
- ◆ convert 300 ha of pine trees back to native species;
- ◆ progressively convert some 1100 ha of exotic trees species within bauxite mined area back to native trees species;
- ◆ attempt to rehabilitate some 1000 ha of dieback areas planted to exotic species in a staged approach back to native species;
- ◆ thin some 1400 ha of bauxite mine rehabilitation planted to native species, mainly jarrah;
- ◆ thin approximately 5100 ha of dense regrowth native jarrah forest (some of this area may be open enough it does not require thinning);
- ◆ review any areas proposed for commercial operations with the FPC; and
- ◆ review proposed prescribed burning programs with CALM.

The objectives for this project are for improved water production and quality (short-term and long-term

benefits) and aiding the development of sustainable forest management in surface water catchments (long-term benefits). There could be commercial logging in native forest within the Wungong Catchment by others during and after the project, and some of the older mining rehabilitation may have commercial products. In the long-term, the management priority for our forests will be the decision of future generations.

In each area to be treated there may be a mix of commercial and non-commercial thinning, although it is expected most of it will be non-commercial. It is difficult to estimate the ratio of commercial to non-commercial for the whole catchment.

It is worth noting that even though some stands may have commercial products, FPC may not wish to use them, either because there is too small a volume, it is too scattered or there may be other areas of higher priority. The use of the products is for FPC and CALM to determine, not the Water Corporation.

The areas of mining rehabilitation would not be treated until there is agreement between Alcoa World Alumina Australia (Alcoa), which is still responsible for rehabilitation of these areas, the State Government agencies and, if necessary, the Water Corporation.

Through the consultation process the key areas of public concern with respect to this project include any potential negative effects on biodiversity (both terrestrial and aquatic) (Section 6.1), the potential effects on dieback spread and intensification (Section 6.1.1.4), use of herbicides on water supply catchments (Section 6.2.2), potential effects on nutrition and carbon storage (Section 6.3), the potential use of the wood produced (Section 6.3) as well as the potential negative effects on aesthetics and on recreational values (Section 6.4). Each area of concern has been addressed in this document. To accommodate these concerns the Water Corporation will use the most appropriate procedures and techniques, work collaboratively with CALM and other forestry experts, implement best-practice silvicultural practice, and design appropriate monitoring and research programs.



Further, the Water Corporation will continue to employ open, adaptive and consultative management processes.

In addition, the Water Corporation believes the proposed rehabilitation and thinning practices will also have some positive effects on the environment, such as increasing the water and timber yields, improving biodiversity (e.g. by removal of exotic species, increased streamflows, retention of additional habitat trees), and a reduction in energy requirements. The proposed changes by thinning and burning may have both benefits and disbenefits to various components of biodiversity. These impacts will be carefully monitored and researched.

Also, the Water Corporation is planning environmental measures to increase conservation benefits from this project (Section 5.6.4).

1.3 Purpose and structure of document

This document will describe the project, environmental issues and management strategies. This document also describes how the project is consistent with the State's Forest Management Plan 2004–2013.

It is also envisaged that the EPA will consider the project and may provide advice to the Minister for Environment on the environmental aspects of this project.

1.4 Proponent

The proponent is the Water Corporation, which is a government business enterprise, whose purpose is sustainable management of water services to make Western Australia a great place to live and invest. The Water Corporation provides commercial water, sewerage and drainage services in an environmentally responsible manner.

1.5 Legislative framework

The Wungong Catchment management project will be subject to a number of Acts of Parliament and

Regulations at State and Federal level including:

- ◆ *Environmental Protection and Biodiversity Conservation Act 1999 (Commonwealth)*
- ◆ *Rights in Water and Irrigation Act 1914*
- ◆ *Wildlife Conservation Act 1950*
- ◆ *Alumina Refinery Act 1961*
- ◆ *Aboriginal Heritage Act 1972*
- ◆ *Mining Act 1978*
- ◆ *Metropolitan Water Supply, Sewerage and Drainage By-Laws 1981*
- ◆ *Conservation and Land Management Act 1984.*
- ◆ *Environmental Protection Act 1986*
- ◆ *Heritage of Western Australia Act 1990*
- ◆ *Native Title Act 1993*
- ◆ *Mining Safety/Inspection Act 1994*
- ◆ *Australian Drinking Water Guidelines 1996*

Frameworks for this project's approval are described in Section 5.7.

1.6 Relation to Forest Management Plan 2004–2013

State forests and timber reserves in the south-west of WA are vested in the Conservation Commission of WA. Forestry activities in these areas are controlled by the Forest Management Plan, which is developed by the Conservation Commission through the agency of CALM (Section 5.7.2). A plan for 2004–2013 has been assessed by the EPA (2003a).

The Conservation Commission's overall objective in formulating the plan is "for biodiversity to be conserved, the health, vitality and productive capacity of ecosystems to be sustained, and the social, cultural and economic benefits valued by the community to be produced in a manner taking account of the principles of ecologically sustainable forest management". (Conservation Commission of WA, 2003).

The Forest Management Plan is implemented by CALM as the land manager. All timber harvesting is the responsibility of FPC, who is therefore responsible for the development of the logging plan and implementing guidelines for harvesting. The preparation of the logging plan is contracted to CALM, and FPC may also contract other works such as non-commercial thinning to CALM. CALM is also responsible for biodiversity conservation; fire management within the forests; assisting the Conservation Commission of WA, Marine Parks and Reserves Authority, and Marine Parks and Reserves Scientific Advisory Committee; promoting and facilitating recreation in CALM managed land; promoting conservation of water quality and quantity; and work with FPC to ensure the development of forest production requirements for the State are consistent with the protection of nature conservation, community, recreation, cultural, catchment and physical values.

As most of the forest on the drinking water catchments is managed by CALM, through the Forest Management Plan, the Water Corporation's Wungong Catchment management project is designed to be consistent with the plan's objectives and intent.

The plan sets the annual volume of commercial timber harvesting and strategies by which the forests are managed. The plan and its associated guidelines allow for a range of silvicultural prescriptions including thinning, gap creation, shelterwood cutting and clear-felling. This project primarily relies on non-commercial thinning, although some (commercial) saw logs and woodchips may be cut (from the older exotic mining rehabilitation areas). If saw logs from native species are cut, this would be managed by FPC, and this timber would form part of the approved annual harvest volume as detailed in the Forest Management Plan 2004–2013.

An important part of the Forest Management Plan are its objectives and key performance indicators (KPI). The Water Corporation will develop its own KPIs (Section 5.5.3) as well as contributing data to relevant Forest Management Plan KPIs (see Appendix 4: Summary of Forest Management Plan).

Three elements of this project that relate strongly to the Forest Management Plan 2004–2013 are the use of non-commercial thinning as a silvicultural method for water and other benefits in an adaptive management framework:

- ◆ As a silvicultural objective, the thinning of forests is recognised within the Forest Management Plan, although in the plan it has a focus for improving timber growth, on page 10 it states “The future productivity of regrowth forests has increased in importance for the yield of sawlogs since timber harvesting in old-growth forest was ended. The plan recognises the significance of conducting early and mid-term thinning schedules to ensure growth is maximised onto utilisable product and includes a number of Actions to monitor that it is occurring”.
- ◆ The Forest Management Plan makes several references to water, in Section 21 on page 51 it states “Water is one of the most widely used products that comes from forests. The quantity and quality of water used for environmental and consumption purposes should be protected and, where necessary and practicable, enhanced”. The action in Section 21.3 on page 49 is “The Department [of Conservation and Land Management] and the Forest Products Commission, in consultation with the Conservation Commission, will evaluate with the Water Corporation and the Water and Rivers Commission [now Department of Environment] any proposal seeking to employ silvicultural treatments to increase the flow of water to surface and groundwater reservoirs”.
- ◆ Adaptive management, a focus of this Wungong project, is part of the Forest Management Plan's method of implementation. In Section 32.2 on page 62 the plan states “The Department [of Conservation and Land Management] will, in consultation with the Conservation Commission, conduct trials, where reasonable and practicable, of improvements to silvicultural and fire management practices”.



1.7 Agency advice on project

1.7.1 Conservation Commission of WA

The Conservation Commission of WA is responsible for the development of the Forest Management Plan 2004–2013, which is undertaken through the agency of CALM. Conservation Commission members and staff were briefed on several occasions and some attended field visits. The Conservation Commission considered the project, and has concluded that it is consistent with the Forest Management Plan provided that some specific actions are undertaken (letter dated 16th December 2004). These actions have been addressed throughout the document but are also detailed below.

This project is an adaptive management research trial and the outcomes of the project will be used to provide more comprehensive information to the Conservation Commission for the development of the next forest management plan. There are also less well understood aspects of the project, including the impacts of thinning and burning (both positive and negative) on elements of biodiversity and water values. Work is planned to examine these effects in more detail. Therefore the Conservation Commission has an important role to play in the development and review of appropriate research and monitoring programs. As such the Conservation Commission will be included in the project's technical reference group, whose role will be expanded to include scoping and reviewing research and monitoring proposals (see Section 5.6.3).

A key point raised by the Conservation Commission as needing research is the silvicultural prescriptions. While the sample prescriptions given in Section 5.5.1 are based on current best practice, this project provides an opportunity to trial a range of different thinning and management prescriptions, including different target basal areas and frequency of thinning, not exceeding the recommended limits of the jarrah silviculture guidelines. Suitably replicated trials will be established in the native regrowth forest (Section 5.2.3) and the bauxite mining rehabilitation planted to native species (Section 5.2.6).

In terms of monitoring, the Conservation Commission identified the need to ensure that monitoring of biodiversity is conducted in a comprehensive manner and can be integrated with other monitoring being undertaken in a manner that will enable extrapolation to other catchments. It is intended that existing monitoring systems (such as CALM's FORESTCHECK and those established by Alcoa) will be used where possible and expanded where necessary.

1.7.2 Department of Conservation and Land Management

CALM is the agency responsible for the management of the land covered by the Forest Management Plan. As such staff from CALM have been involved in the development of this project from the outset, through site visits, meetings and as members of the policy and technical reference groups (see Sections 5.8 and 5.6.3). It is CALM's conclusion (letter dated 7 January 2005) that the project is consistent with the objectives and actions of the Forest Management Plan, specifically:

- ◆ the objective for the management of regrowth stands in Section 16 on page 38, that seeks "... to realise the productive capacity of the forest", and the associated Action 16.1.2;
- ◆ the objective in Section 19 on page 45, that aims "... to develop self-sustaining ecosystems of native species from regeneration or rehabilitation operations in native forest", through Action 19.1.1;
- ◆ the objective to manage the forests for water in Section 21 on page 49, that looks to "... increase the flow of water to surface and groundwater reservoirs";
- ◆ the objective for the use of adaptive management in Section 33 on page 62, that aims to "... provide for adaptive management to improve forest management"; and
- ◆ the objective for the generation and transfer of knowledge in Section 38 on page 64, "... with a view to leading to improvements in forest management".

In addition, CALM confirms that the project has identified all proposed formal reserves, informal reserves and indicative fauna habitat zones, which are the areas to be excluded from all silviculture except prescribed burning (see Section 5.2.1). In the areas where treatment is to be carried out, the implementation will be consistent with the jarrah silvicultural guideline, and therefore will be in accordance with the Forest Management Plan.

While CALM considers the project to be consistent with the Forest Management Plan in the broad sense, both CALM and the Water Corporation are aware that there is still a great deal of detail that needs to be developed over the project's life.

As such both have identified the need for a formal inter-agency structure and process for the discussion on implementation and management issues in the long term. The Water Corporation supports this cooperative approach to the Wungong project (see Sections 5.7 and 5.8) and will work with the relevant agencies in developing these structures and processes.



2 Community Consultation

The Water Corporation has endeavoured to be open and inclusive during the development of this project. Because this project has wide stakeholder interest and importance, consultation is vital. This consultation is part of the partnering approach the Corporation is taking to provide the most sustainable outcomes aimed at meeting community expectations.

Community consultation on catchment thinning has been a feature of past water planning, such as Perth's Water Future and the State Water Strategy (described in Sections 3.2.2 and 3.2.3). For this project, the initial consultation was a briefing requested by interested members of Parliament on 7 and 8 May 2002. This briefing was called in the light of low storage levels in the IWSS's major dams. The briefing described the understanding, based on past local research, of how catchment management could increase water yields. The feedback from the briefings was positive as there was a realisation that there could be environmental, as well as water benefits, so the issue was taken further.

A series of presentations and meetings were held during 2002 and delivered initially to those who had a history of interest in forest management, in particular those the Water Corporation considered would have concerns about the ideas presented. Following each presentation held, the project was modified as improvements were suggested. No fatal flaws were found. At that stage the project was generic to catchment management for the environment and water in all the IWSS water supply catchments.

On 27 September 2002, the Water Corporation arranged a field trip around the Wungong Catchment, as it was close to Perth and contained a range of forest types. Specific stakeholders were invited for their interest and technical understanding of catchment and forest management. A total of 26 people attended. Sites visited included Alcoa's thinning trial in rehabilitated bauxite pits, a discussion on stream ecology led by the Department of Environment (DoE), the Langford Park recreation area, an old-growth forest

near Jarrahdale, thinned and unthinned regrowth forest at Mundlimup (Figure 3), some dieback sites, the pine plantation at Gleneagle and the Wungong Dam. A list of attendees and locations visited are given in Appendix 3: 27 September 2002 field trip.

Following feedback from stakeholders in late 2002, the decision was made to:

- ◆ choose a specific site for an operational scale field trial (Section 3.4);
- ◆ develop specific treatment prescriptions (Section 5.2);
- ◆ consult further with stakeholders once a draft was available (over 100 copies were distributed for comment);
- ◆ prepare a public document for EPA evaluation (this document).

During 2003 and 2004 the project in this document was discussed with stakeholders. Table 1 lists the Water Corporation presentations given to groups of stakeholders. There have been many other less formal communications.

On initially hearing about the project, stakeholder feedback ranged from negative and cautious through to positive. In general, after discussion of the issues, stakeholders were supportive of the adaptive management project and the process the Water Corporation has used to engage with stakeholders. Areas of the project that have potential for negative and positive impacts are discussed in Sections 6 and 7. Some issues raised are outside the direct control of the Water Corporation but highlight the interest in forest management.

The emphasis of the Water Corporation's stakeholder consultation has been with peak organisations. The Water Corporation has also run three focus demographically diverse groups with members of the general public.

There were also telephone interviews with some members of the community who live near Wungong Catchment. Water Corporation used feedback from the focus groups and telephone interviews to help develop a communication program that addresses issues the public have with the project.



Figure 3 Stakeholder consultation during Wungong Catchment field trip, September 2002
(Photos by Colin Terry)





Table 1 Stakeholder group presentations for project

What	When	Who
Catchment management for water and the environment	7 and 8 May 2002 28 May 2002 1 July 2002 4 July 2002 5 July 2002 8 July 2002 21 August 2002 17 September 2002 18 September 2002 27 September 2002 7 November 2002 13 November 2002 29 January 2003	Interested members of Parliament Water Corporation staff WA Forest Alliance Department of Environment (DoE) staff Murdoch University staff Conservation Commission of WA Forest Products Commission (FPC) senior staff Serpentine-Jarrahdale Shire Water Corporation Customer Council 26 people on field trip Conservation Council of WA Interested members of Parliament Department of Conservation and Land Management (CALM) senior officers
Wungong Catchment management project	2 August 2003 7 August 2003 27 August 2003 29 August 2003 3 September 2003 4 September 2003 6 September 2003 13 October 2003 16 October 2003 12 November 2003 17 November 2003 18 November 2003 20 November 2003 9 February 2004 16 April 2004 20 April 2004 27 April 2004 29 April 2004 1 July 2004 3 August 2004 16 September 2004 20 September 2004 21 & 22 September 2004 24 September 2004 21 October 2004 29 November 2004	Water Corporation staff on field trip Water Corporation staff The University of WA (UWA) staff and students Alcoa and Mining and Management Planning Liaison Group FPC senior staff CALM senior officers and Conservation Commission DoE staff Conservation Council of WA Serpentine-Jarrahdale Shire Murdoch University Environmental Sciences CALM senior officers Environmental Protection Authority (EPA) Service Unit on field trip EPA Board Engineers Australia Hydrology and Water Resources Panel (public) City of Armadale and Landcare (public) Murdoch University Biological Sciences Leschenault Timber Industry Club Conservation Council of WA Pastoralist and Graziers Association (by phone) Indian Ocean Climate Initiative Panel, and Australia Greenhouse Office officers Forest History Society conference in Augusta UWA Natural Resource Management students while on field trip in Wungong Catchment Three focus groups from general community South-West zone of the WA Local Government Association South-West Aboriginal Land and Sea Council Conservation Commission and CALM field trip

3 Development of the project

3.1 Need for project

The low volumes in the surface water storages since the record low inflows of 2001 has reminded the Western Australian community of the importance of a reliable water supply. Even with the successful implementation of the current 2 day per week sprinkler usage water restrictions and planned reduction in per capita consumption, as our population grows with a potential hotter and drier climate – access to more water sources is essential.

Compared to the mature old growth forest that grew in our catchments before European forest manipulations, the existing regrowth forests can use more water (see Appendix 2: Forests compared). The impact of a drier climate on a forest which has a greater ability to use water will impact the terrestrial and aquatic environments as well as our water supplies. In the drier areas of our catchments the *Eucalyptus wandoo* has shown crown decline for more than a decade (Figure 4). The cause of the decline is being researched, but potential factors raised by University researchers include reduced rainfall, increased temperature, salinity, pests and over-stocking. Recent measurements record a drop in water table up to 8 m from 1975 to 2004.

Past catchment management has not focused on water quantity and there is an opportunity to combine water and forest management, facilitated by the value of water generated through the thinning, to improve run-off and the environment (Terry et al., 2004).

To some proponents of minimal forest management, a 'no action' approach may seem desirable within the Wungong and other water supply catchments. But this may not be feasible in practice and may not deliver outcomes that are seen as desirable for biodiversity conservation, water and forest management. The application of the precautionary principle with respect to strong likelihood of continued drying change, drought deaths and more fires is to take positive measures now.



Figure 4
Crown decline in *Eucalyptus wandoo* in eastern Mundaring Catchment (Photo by Colin Terry)

3.1.1 Protected areas

Already a large part (26%) of the Wungong Catchment is proposed to be excluded from thinning (Figure 18). These areas include buffers around stream zones and diverse ecotype zones (such as rocky outcrops), and experimental controls. Further areas where no thinning will take place are the Fauna Habitat Zones, as required under the Forest Management Plan 2004–2013. Only indicative fauna habitat zones have been used at this stage, and more work in consultation with CALM is required to determine final boundaries. It is estimated that the inclusion of the Fauna Habitat Zones will increase the area excluded from thinning to 38% of the catchment.

The protected areas are proposed for routine prescribed burning by CALM in accordance with its policy on hazard reduction and the enhancement of biodiversity.



It is noted that the current CALM prescribed burning activities have recently been the subject of a review by EPA.

Burning regimes in the forests need to be designed with the requirements of threatened species in mind. As such, some of the protected areas may well require a particular frequency and intensity of burning to favour threatened species such as the quokka. It is believed that these marsupials require feeding areas (usually less than 10 years old from burning) as well as habitat areas (where the vegetation is more than 20 years in age), in conjunction with feral animal control to reduce predation.

3.1.2 Mined areas

Within the areas mined and rehabilitated by Alcoa, this project facilitates management by thinning and burning when Mining and Management Program Liaison Group (MMPLG) completion criteria issues are resolved to the satisfaction of Alcoa and CALM. While the completion criteria themselves have been agreed on, no areas of mining rehabilitation have yet been taken back from Alcoa by the State to be managed by CALM.

Some of the areas rehabilitated to jarrah are already extremely dense at a young age (e.g. basal areas greater than 40 m²/ha, over 2000 stems/ha, at age 12 years) while other, older stands of exotic species are also dense.

Thinning is proposed within these stands to relieve moisture stress, to favour native species over exotic species, to concentrate growth on fewer, better stems and to favour a greater degree of biological diversity as all the dense stands were noted to lack both understorey and ground flora components. Prescribed burning will be required to protect these thinned stands from damage by wildfire and to discourage regeneration of exotic species.

If these stands are not treated by thinning, their growth rates will be much reduced. Also if rainfall continues to reduce crown dieback may increase and drought deaths may well occur in the future. Any stand that is under stress is also more likely to be damaged by disease and insect pests.

Should these stands be burnt by a wildfire, very dense regeneration of both exotic species and native wattles will be encouraged. These areas will then be most difficult to access, the dense regeneration will eventually place a great stress on the site for water and nutrients, the areas will be very difficult to burn and much more expensive to thin.

3.1.3 Jarrah forest

Given recent public concern at proposed logging operations in the Serpentine and Mundaring catchments, it is quite likely that proposals by FPC to commercially log jarrah forest in the Wungong Catchment and for the non-commercially thinning of some stands of native jarrah within the catchment will be seen as the more controversial aspects of this project. The Water Corporation has therefore held several discussions on the project with the Serpentine-Jarrahdale Shire, Armadale Shire, WA Forest Alliance, Conservation Council of WA and community focus groups to ensure ongoing liaison and input.

Currently the areas of State forest on water supply catchments are designated for logging under the Forest Management Plan, and the volumes that they contain have been included in CALM's sustainable yield calculations. Should it be decided that all areas of State forest that are on water supply catchments be excluded from logging, approximately 288 000 ha of land would be affected and the calculated sustainable yield will be seriously compromised.

Should areas be proposed for logging by FPC in the short-term (within 5–10 years), it would make sense for the Water Corporation's non-commercial thinning to be delayed until this logging has occurred, which is standard procedure. Should the proposed logging be deferred for over 10 years, it would be appropriate for non-commercial thinning to be implemented to enhance water yield in the interim and to concentrate growth on the future crop and habitat trees.

3.2 Planning context

3.2.1 Forest management

Forest management should be ecologically sustainable and water has been considered as an aspect of forest management for some time. For example, the 1921 Mundaring Working Plan had water production as the primary objective followed by wood production (Stoneman et al., 1989) and the Forests Department (1980) proposed Water Production Priority Areas in the high rainfall zone in its Land-use Management Plan. The Conservation Commission's 2004–2013 Forest Management Plan (Conservation Commission, 2003) also recognises water as an important value. In the section on Soil and Water in the plan, silvicultural treatments to increase flow of water are considered and these would be evaluated by CALM and FPC in consultation with the Conservation Commission if proposed.

3.2.2 Perth's Water Future

In the document 'Perth's Water Future' (Water Authority of Western Australia, 1995) a strategy for providing a reliable water supply-demand balance was created through a consultative process. This included demand management, identification of possible new sources, and consideration of strategic issues (such as understanding climate change and domestic water usage).

The mix of possible new sources ranged from the conventional surface and groundwater schemes, to the less conventional such as icebergs and transporting water from the Kimberley. Included in these options was catchment thinning, which was seen as economically low cost, but with social and environmental issues that needed to be worked through before it could be considered a water source.

The then Water Authority of Western Australia (which in 1996 became the Water Corporation and the Water and Rivers Commission) committed to continue investigating catchment thinning for water supply by building on the past research.

3.2.3 State Water Strategy

In 2003 after several community based water forums and a water symposium in 2002 – the Premier of Western Australia, Dr Geoff Gallop, released 'A State Water Strategy'.

The Premier committed to a catchment management trial for water quality and quantity by stating to "Support development of improved catchment management activities and undertake a research trial to investigate the impact of active catchment management strategies that enhance water quality and quantity outcomes".

The Wungong Catchment project has been developed to fulfil that commitment.

3.2.4 Security through diversity

The Water Corporation is progressing several projects to maintain a supply-demand balance with a 'security through diversity' approach (Figure 5). The Water Corporation examines the economic, social and environmental aspects of these projects, to ensure its management of water services is sustainable. Catchment management is one of these projects, and this 4–6 GL trial in the Wungong Catchment is a pilot for a potential longer term 40 GL water source.



Reducing the water usage per person and recycling treated wastewater will delay the need to develop new water sources. Conversely, the steady increase in WA's population, a drying climate and need to reduce the impact on the groundwater system requires the development of new water sources. There is a proud history of water planning in WA and a wide range of water source options have been identified to ensure the security of WA's public drinking water supply. The timing of when new sources are developed will be to maintain this security of supply, while minimising the economic, social and environmental impact of developing water sources too early.

It is unwise to invest in infrastructure that is not required, when that money could be used for more worthwhile causes. Similarly once the investment has been made, it is worthwhile maintaining those assets and using them to their full potential. In this context, this Wungong Catchment management project is to make effective use of our existing surface water infrastructure, in this case the Wungong Reservoir (the body of water), its dam (the structure controlling the water) and associated pipes and controls.

3.3 Alternatives

Maintaining a supply-demand balance is important for providing a secure water supply to the community. Demand management is an important part of this balance, although even with a reduction in the amount of water each person uses, due to population growth, there is a need for new water sources. It is worth comparing the current water sources being considered in a sustainability framework. While demand management and the other water sources the Water Corporation is currently considering are complementary to catchment management, all have their benefits and risks.

A comparison of water sources being considered is shown in Table 2. This comparison is not exhaustive, but does provide examples of the differences and similarities between the options. In Table 2 the long-term 40 GL catchment management option is given for comparison with the other options (note this document describes what could be a 4–6 GL first stage of the 40 GL catchment management option).

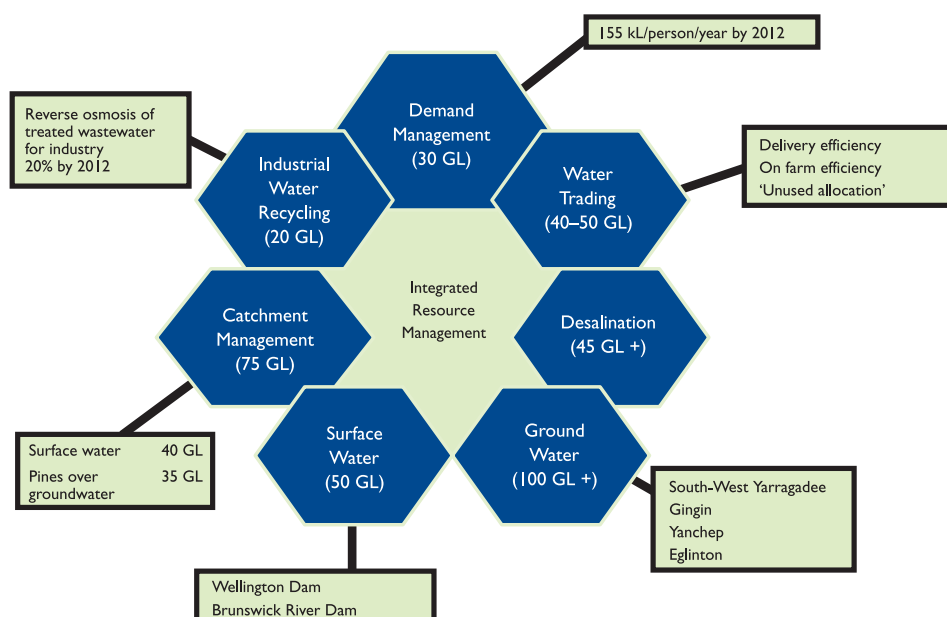


Figure 5 Water Corporation's security through diversity projects' annual water benefits

The number of gigalitres is the option's annual water yield. Water consumers in the IWSS, with current sprinkler restrictions, use approximately 261 GL annually (increasing at approximately 1.5% per year).

Extra streamflow from catchment thinning is captured in existing water supply infrastructure. These dams and pipes mostly use gravity and not pumping to supply water to the community. Pumping is energy intensive, expensive and results in creation of extra greenhouse gases. Catchment thinning is a longer term option and can not deliver water as quickly or reliably as the groundwater and desalination options. This is a significant issue given the low volumes in the surface water storages and possibility of continued low rainfall. Because of this, other sources in addition to the Wungong Catchment management project will need to be developed.

The unit cost from Table 2 is used to compare the economic cost of the four most prospective water source options on an equal basis. It is the present value of all the capital and operating costs, divided by the present value of the water delivered from the source. The development cost for the longer term catchment thinning water source is less than half of the next cheapest source. The Wungong Catchment forest enhancement project will annually provide an additional 4–6 GL at the low cost of 23 cents per kilolitre (\$0.23/kL), with the possible longer term project costing \$0.20/kL. The cost includes money for research, monitoring, auditing and additional environmental benefit projects.

Table 2 Water source options comparison

	Catchment thinning	Water trading	SW Yarragadee	Desalination
Unit cost	\$0.20/kL	\$0.50/kL	\$0.85/kL	\$1.11/kL
Yield	40 GL	18 GL	45 GL	45 GL
Energy use	Effectively zero*	< 0.5 kWh/kL	1 kWh/kL	4.5 kWh/kL
Examples of social and environmental issues	Controversial? Environmental benefits?	Irrigation industry more efficient and sustainable	Local water needs and groundwater dependent ecosystems	Greenhouse gases and ocean discharge of brine
Asset creation	Existing assets	Existing and new	New assets	New assets
Timing	10–30-year delivery	3–4 year delivery	2-year delivery	2-year delivery
Source weakness	Linked to annual rainfall	Linked to annual rainfall	Linked to average rainfall over many years	Linked to energy supply
Source reliability	Medium-high	Medium-high	High	Very high

***Note** that while more work will be done during the project on analysing this, conceptually although there is dead wood produced from thinning that releases carbon, the retained trees grow faster and act as a carbon sink (see Section 6.3)



3.4 Site Selection

There are several reasons why the Wungong Catchment was considered to be a suitable experimental site. These are listed below, but not in any order of perceived importance:

- ◆ It is a discrete catchment that is small enough for treatments to be significant and measurable.
- ◆ The catchment has been well gauged for some decades at several stations. There are also a number of rainfall stations on or near the catchment, some with very long records.
- ◆ The proposed treatment area will be large enough to be economically useful (4–6 GL).
- ◆ The water is gravity fed to the metropolitan area and the energy requirement is low.
- ◆ It is located at the northern end of the humid, high-rainfall zone and should be representative of the high-rainfall areas of other metropolitan water supply catchments.
- ◆ It is located in the high-rainfall zone, where research has indicated that there will be no significant adverse impact on salinity.
- ◆ The catchment can be taken off-line quickly if necessary without disrupting essential water supplies.
- ◆ It is located close to Perth and is accessed by major roads. This is an advantage for monitoring and for research (especially by tertiary institutions and students). It is also accessible by secondary roads and the public for education and extension tours or by the public for recreational activities.
- ◆ The area is far from pristine and now contains no old-growth forest, having been disturbed by farming, several logging operations (e.g. 57% logged three times and 6% logged four times), prescribed burning, pine plantations, dieback and mining.

- ◆ Availability of historical land-use data.
- ◆ Other data are available on soil, landforms, biodiversity values (including flora, vegetation and fauna) as well as research data on hydrologic, silvicultural and nutritional values.

The monitoring and research outcomes from the Wungong Catchment management project could lead to the development of improved prescriptions for other catchments to enhance environmental and water outcomes. Should this Wungong Catchment management project proceed and receive ongoing public, EPA and government support and the results of monitoring and research show that the trial successfully meets all its objectives, consideration would be given to treating other catchments.

4 Overview of existing environment

4.1 Location and description

The Wungong Catchment lies on the western margins of the Darling Plateau located in the south-western margin of the mostly arid and ancient Great Plateau (Dell et al., 1989). The Wungong Catchment occurs on extensively laterised landscapes of the northern parts of the Darling Plateau. The Wungong Catchment occurs on the Wungong Brook, which developed following deep weathering of the uplifted ranges (Figure 6). To the north-east and east of the Wungong Catchment there are a series of peaks (Eagle Hill, Mount Cooke and Mount Windsor) which are remnants of the older and higher plateau. An overview of the Wungong Catchment is:

- ◆ 12 845 ha catchment area (128 km²);
- ◆ mainly State forest (Figure 7);
- ◆ logged up to four times;
- ◆ plantations 300 ha;
- ◆ mined and rehabilitated 2500 ha; and
- ◆ over half of the catchment dieback affected and some areas rehabilitated.

The Wungong Catchment is dominated by an open forest of *Eucalyptus marginata subsp. marginata* (jarrah), *Corymbia calophylla* (marri) and *Allocasuarina fraseriana* (sheoak) on the laterised slopes and a mixture of *E. patens* (yarri) and *E. rudis* (flooded gum) in the main valley floor. There are scattered sedimentary areas on the upper gullies that have higher contents of sand and clays in the soils and consequently support different plant communities.

4.2 History of Wungong Catchment management

The values on any catchment are constantly changing in response to changes in climate, underlying soil conditions, changing fire regimes and the activities of people, either directly or indirectly. As a result, there have been many changes within the catchment through time.

The earliest involvement by the traditional owners, the Noongar people, would have included travel through the area, hunting and a form of fire-stick burning practice (Hallam, 1975; Pearce, 1989). The next phases would have involved activities associated with the small coaching inn (located just outside the catchment) and the associated small orchard on Albany Highway and developments associated with the much larger mill town of Jarrahdale, established in 1872, which is located just to the west of the catchment boundary (Mills, 1989).

4.2.1 Forestry

The early millers exploited the adjacent old-growth forest by removing all large and undamaged trees, with little controls. There was heavy cutting and some clear-felling (removing up to 90% of the basal area), with substantial waste and these activities were inevitably followed by large and uncontrolled fires. Some vigorous regeneration resulted and is seen today as dense regrowth stands such as those in the Mundlimup forest block. By 1899 Jarrahdale and the surrounding mill towns had about 300 workers and a total population of about 1200 people and used up to 140 horses and 100 bullocks for log-hauling, as well as 100 km of tramway (Fall, 1972). There was one major access route through the upper Wungong Catchment that led to the Gleneagle area. By 1902 the sawn output is recorded as 40 000 loads (57 000 m³) that would have required an annual log intake of about 175 000 m³. Sawmilling continued uninterrupted at Jarrahdale until September 1997.



The information contained herein is subject to ongoing review and amendments and should be read in conjunction with the associated report



Legend

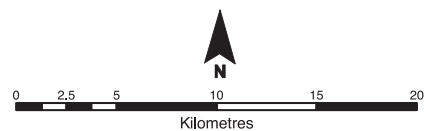
Wungong Catchment



Water course



Road



Wungong Catchment location near Perth



Data obtained from Department of Environment and Department of Land Information

Figure 6 Location of Wungong Catchment near Perth, Western Australia

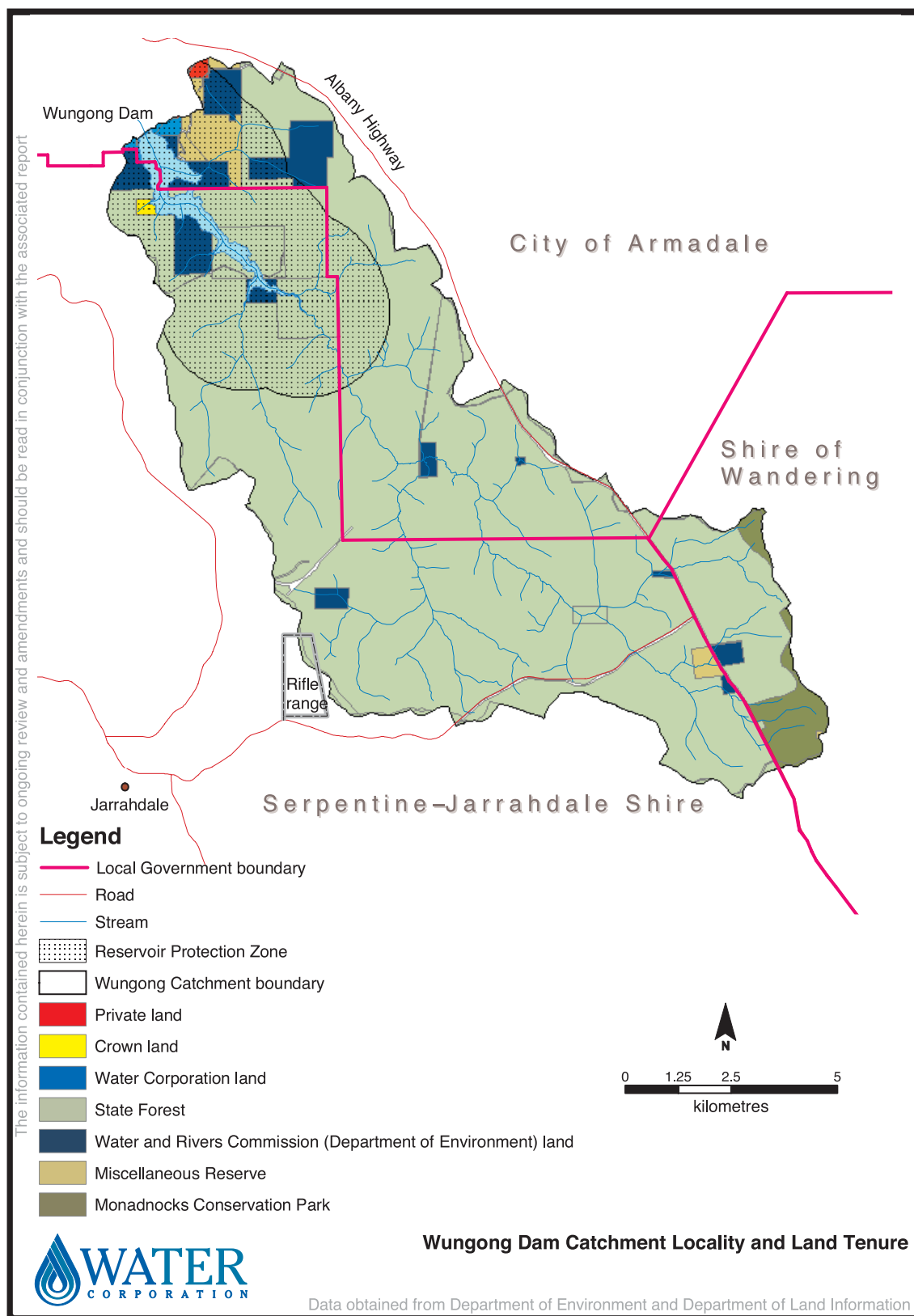


Figure 7 Wungong Catchment land tenure



The Forests Department was only established in December 1919 with few staff. Prior to that time a small forestry unit, that was largely responsible for revenue collection existed in the Lands Department. The Forests Department's records show that the area in this catchment was reserved as State forest during the period 1924–1930 (Havel, 1989). Other data obtained from CALM show that most of this catchment was first logged well before 1920, with few if any controls. It is of interest that the Forests Department Annual Report as early as 1928 states "On portions of the (Jarrahdale) Working Circle there are good stands of regrowth that have reached the pole and pole stage, and that urgently need thinning. One hundred and seventy three acres in Mundlimup block were given a crown thinning during the year...(1928)". The estimated reduction in basal area was by about 36%.

Initial forestry administration for this area was from Kelmscott, but then before World War II it was moved to Gleneagle. There was also a much smaller settlement at Mundlimup. Eventually the staff and facilities were relocated to Jarrahdale and Kelmscott in 1963–64. Subsequent logging within the State forests took place under tree-marking to remove any remaining damaged mature and over-mature stems and retaining poles and pole-sized stems. Records of logging are available from CALM by the decade of the cut and show that large areas within the catchment were cut-over in 1930–49 (10 600 ha) and 1970–89 (7200 ha). Overall, 9% of the catchment area has been cut-over once, 26% twice, 57% three times and 6% four times.

Logging is normally followed by growth in the canopy of the retained stems and by regeneration of the eucalypts and understorey species through coppice, lignotuberous advance growth or seed. The initial effects of logging on increasing water yield are therefore likely to be transient (Stoneman et al., 1989).

However, the longer term effects when old-growth stands are replaced by dense regrowth stands are considerable as these smaller trees have a greater water conducting potential (Figure 23). Unlike the *Eucalyptus diversicolour* (karri), without intervention the jarrah and marri regrowth, that dominates the IWSS catchments, will remain locked up as dense pole stands for many years. If it survived at all it would probably take 300 years to grow from 20 to 50 cm diameter (Stoneman et al., 1989).

Data from eucalypt forests in New South Wales (Roberts et al., 2000) indicate that reductions in water yield that averaged 30% were recorded for *E. sieberi* regrowth stands aged between 8 and 20 years. Similar studies in Victoria with 20–40-years-old regrowth of *E. regnans* showed a reduction in water yield of between 50% and 60%.

Because the forests in the Wungong Catchment were cut-over well over 100 years ago, there are no data available on historical water yield prior to white settlement and of the effects of changes in land-use on the long-term water yield for the northern jarrah forest. However, research has shown that thinning of regrowth stands can substantially increase water yield (Stoneman et al., 1989; Bari and Ruprecht, 2003).

Underwood and Christensen (1981) recorded early recognition of the inability to totally protect the forests from fire. The fire lookout towers and telephone lines to the towers were the main means of fire detection prior to 1954. The Forests Department also introduced fire protection measures in State forests, initially practicing a policy of fire exclusion, then, when this failed by dividing the forest into 200–400 ha compartments surrounded by firebreaks between 100–200 m wide that were burnt frequently (McCaw and Burrows, 1989). A change in policy was introduced in 1954 that involved the introduction of widespread prescribed burning to provide for hazard reduction by removing ground fuels (McCaw and Burrows, 1989).

Data provided by CALM show a substantial increase in the use of fire on this catchment post-1950, with 17 500 ha burnt between 1960 and 1969. This trend continued until the 1990s. More recently, there has been a reduction in prescribed burning as a result of various factors. Fire management has become increasingly more complex with a changing climate, community concerns over smoke, and management objectives covering biodiversity, fire-risk reduction and asset protection.

Positive effects of prescribed fire on increasing water yield is likely to be transient as the canopy and understorey recover – previously in the order of two years. However, large wildfires can have a dramatic effect on water yield, as well as negative impacts on water quality. McArthur (1964) notes that there was a 72% increase in the yield from the North Dandalup catchment in the 1961 winter, following the devastating Dwellingup fire the previous summer that burnt the whole of this 15 000 ha catchment. By 1962 the flow was recorded as ‘very nearly normal’. Where areas have been unburnt for more than a decade streamflow will decrease.

The township of Jarrahdale was substantial and required food for workers and their families as well as the large number of animals used for log-hauling. A number of small farmlets, orchards and market gardens were established in surrounding areas, including some in the Wungong Catchment. It is estimated that the cleared areas would not have exceeded 400 ha in total, with only a small increase in water yield.

The Metropolitan Water Supply, Sewerage and Drainage Board first established a pipehead dam on the Wungong in 1925. Because of Board concerns with various sources of potential pollution, these small blocks were progressively purchased or resumed and then reforested, often to pine species. By the mid-1950s all farming activities within the catchment had ceased.

The use of the pipehead dam continued for several decades until the Wungong Dam of 60 GL storage capacity was constructed and became operational in 1979 (Figure 8). The water is gravity-fed to the metropolitan area. Thus logging and regeneration occurred well in advance of the water supply development. Unlike the catchments that supply Melbourne or some of the southern forest areas in Western Australia, this local catchment has not exhibited old-growth water yield characteristics since being utilised and gauged for water supply purposes.

During the early 1950s, the Forests Department commenced planting pines on resumed farmland, on areas affected by dieback especially alongside Albany Highway and at their divisional headquarters at Gleneagle. These plantations, mostly of *Pinus pinaster*, total about 430 ha of which 290 ha are within the catchment (Figure 9). Some of the pines that were planted on lateritic sites have failed to grow well, but others are growing at much faster rates than jarrah, with presumably a higher water use (Butcher and Havel, 1976). These pines were clear-felled by the Forests Products Commission in the summer of 2004, and now is an appropriate time to consider the future use of these sites.



Figure 8 Wungong Reservoir and dam intake structure (Photo by Mike Thorman)

Mike Thorman, 2003



4.2.2 Dieback

Dieback disease caused by the fungus *Phytophthora cinnamomi* has also had a major influence on the forest ecosystem and on water yield in this catchment. Data collected from aerial photographs show the presence of this disease in this catchment in the 1940s. Since then the spread has been plotted on photos taken at various dates to provide an indication of rate of spread (Batini et al., 1980). About 30% of the catchment was mapped as affected in 1973 and a more recent estimate by CALM on a sample that covers half of the catchment indicates that 42% of the mapped area was classified as infected (Figure 10).

Dieback disease has a major impact on reducing basal area and canopy cover and is often associated with drainage lines that correspond with the generally accepted 'source areas' that generate most of the stream-flow. A study by Batini et al. (1980) within the Wungong Catchment showed a highly significant correlation ($r^2 = 0.931$) between dieback presence and streamflow. The calculated increase in yield was 6 mm/a for each 1% reduction in canopy cover (range 3.5–8.5 mm). The rehabilitation of some dieback areas as practised by the State and required by the State from Alcoa may well have reduced these observed increases in yield.

4.2.3 Mining

Mining for bauxite commenced near Jarrahdale in 1963 and extended into the catchment by the late 1960s (Bartle and Slessar, 1989). It then continued within the catchment until 1998 when the Jarrahdale mine was decommissioned, with a total of approximately 2500 ha mined and rehabilitated (Figure 9). Originally responsibility for rehabilitation fell on the State and the initial techniques were very basic, minimal topsoil return or fertiliser, no battering of the banks, planting with exotic tree species and no seeding with understorey species.

As expected over a period spanning three decades, these procedures improved substantially (Bartle and Slessar, 1989; Ward et al., 1996; Gardner, 2001). From 1979, the responsibility for rehabilitation rested with Alcoa. Currently, all pit walls are battered and landscaped, there is maximum use of fresh topsoil return, dieback hygiene techniques are implemented, the pit areas are deep-ripped with a winged tine on the contour, absorption banks are built to contain run-off, the areas are seeded with a mixture of native canopy and understorey species, fertiliser is added and hard to grow species are grown in nurseries, planted and then given additional protection from native grazing animals (Gardner, 2001). The rehabilitation work by Alcoa has been recognised with several State and international environmental awards.

Clearing of forest for mining substantially increases water yield for some years (Schofield et al., 1989). Extensive monitoring of water quality over many years showed no significant increases in salinity and no major events where acceptable levels for turbidity were seriously exceeded. The rehabilitated stands are progressing with little evidence of self-thinning (Ward and Koch, 1995) and some are upwards of 25 years of age. These dense stands of regrowth have the potential to reduce water yield, possibly even below the original yield from native regrowth forests. Management practices and thinning may also provide an opportunity to rehabilitate areas that were originally planted to exotics with species that are native to these sites.

Alcoa has recently conducted an operational forest management project in the Banksiadale sub-catchment of the South Dandalup Catchment. The project involved thinning of mining rehabilitation and native forest within the sub-catchment. This project has been successful in generating extra streamflow that will be used on Alcoa's nearby Huntly mine site. The 337 ha Banksiadale sub-catchment contained forest types that are common to the Wungong Catchment, and experience gained from the Banksiadale project has been used to help develop this project document.

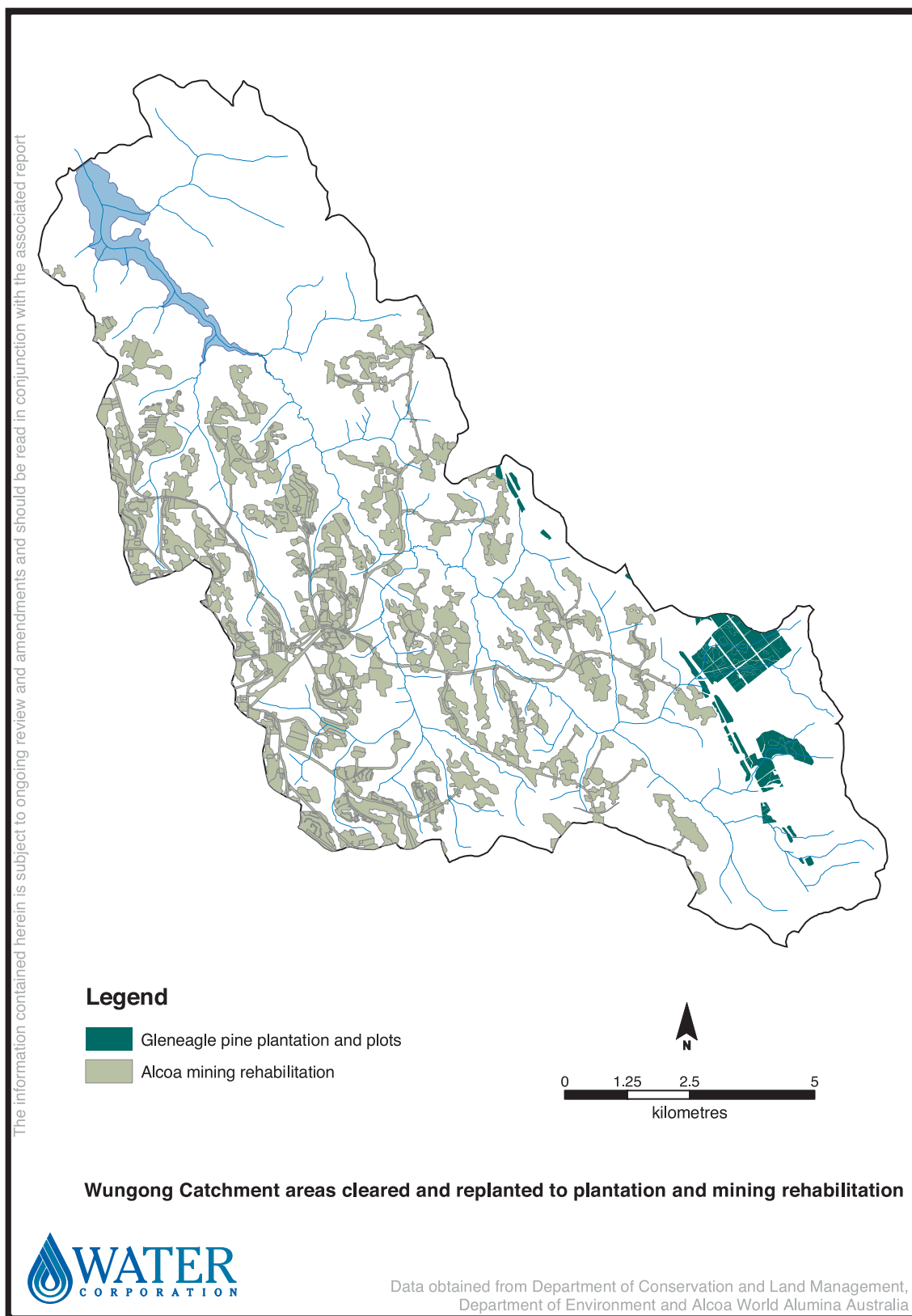


Figure 9 Wungong Catchment areas cleared and replanted

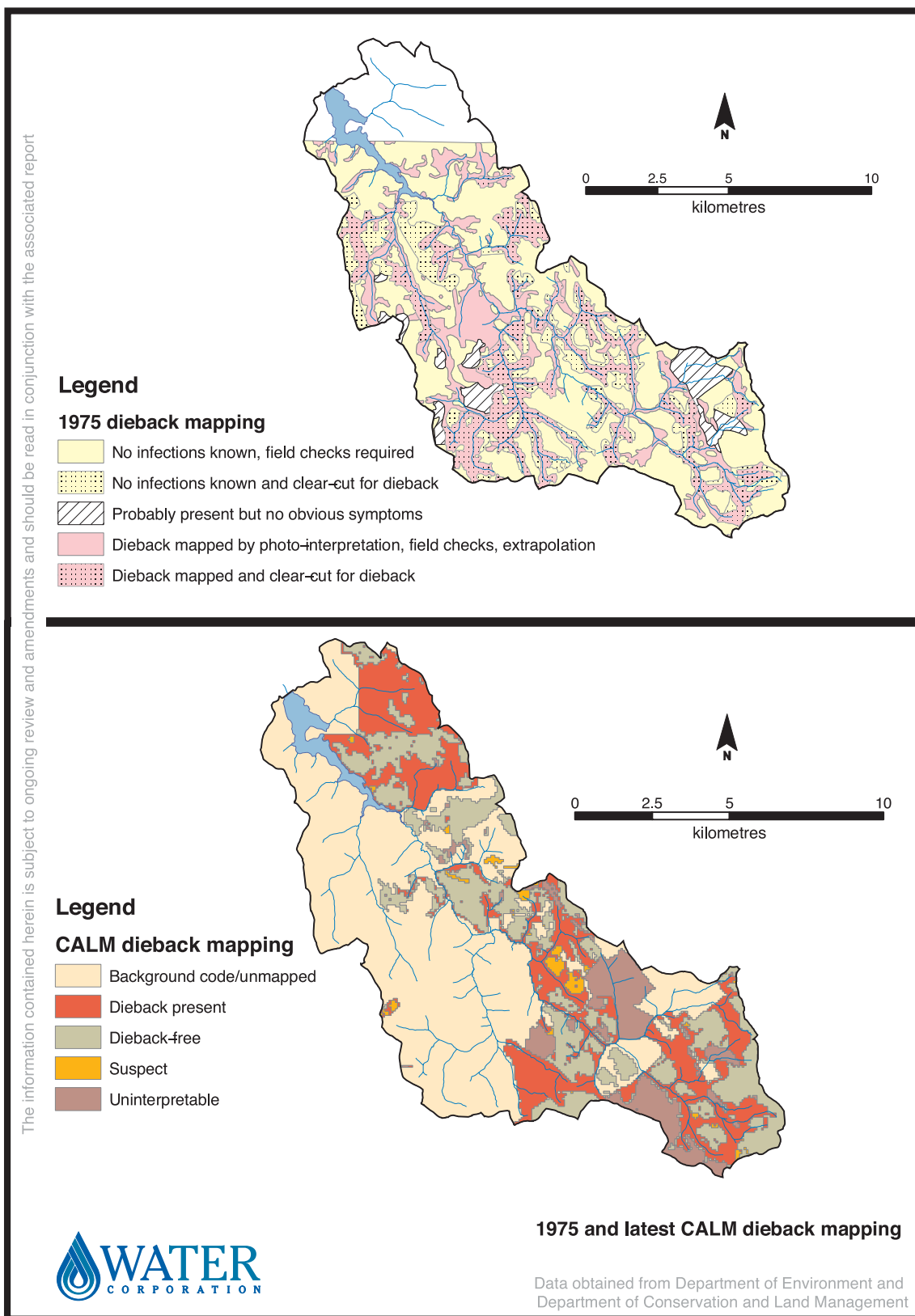


Figure 10 Dieback mapping in Wungong Catchment

4.3 Catchment Hydrology

A manually read staff gauge installation was established on the Wungong Brook in 1911 at the site of the future pipehead dam, with a float operated recorder installed in 1930. Additional stream gauging stations were established in the 1960s at Seldom Seen, More Seldom Seen, Waterfall Gully, the Wungong Brook at Vardi Road in 1982 and Cobiac from 1992–98 (Figure 11). There are a number of rainfall stations in or near the catchment, with the longest record, of over 100 years taken at Jarrahdale. Wungong Catchment is typical of most catchments in the south-west of WA and is dominated by winter streamflow.

It is of interest that this small pipehead source was able to operate for over 50 years, during periods that saw major changes in land-use practices within the catchment. Although after heavy rainfall the pipehead was sometimes turned off due to high turbidity levels. During the life of the pipehead the main action taken by the water authorities was the purchase and resumption of privately held farmland to reduce the possibility of pollution. On historical evidence, extensive logging, recurrent prescribed fire, small pine plantations, major areas affected by dieback disease and extensive bauxite mining and rehabilitation have not seriously affected the water quality through pollution, turbidity or increases in salinity.

The actual effects of these changes in land-use on water yield are more difficult to evaluate. The response of vegetation to land-use is dynamic, with leaf areas initially decreasing but then often increasing beyond the leaf area levels of the original stands. The positive effects of some changes (e.g. dieback disease) on water yield can run counter to the negative effects of others (e.g. regrowth).

Some of the land-use changes have been extensive in area but their hydrological effects decay rapidly. Others are more restricted in area but have a greater magnitude and their effect may not decay for at least a decade. The implications of these changes, their aerial extent, the initial impacts, rates of decay and final steady-state need to be considered when analysing the rainfall/run-off records for this catchment. There has been extensive research into the hydrology of the northern jarrah forests that has been reviewed by Schofield et al. (1989) and added to subsequently by Ruprecht et al. (1991) and Ruprecht and Stoneman (1993). If one includes Doley's pioneer work on jarrah hydrology (Doley, 1967) there is some 50 years of data.

The amount of streamflow is a small fraction of rainfall with most water leaving the catchment as evapo-transpiration (Figure 12). The factors controlling transpiration are shown in Table 3. The average streamflow as a fraction of rainfall for the post-1975 climate is 5% for Perth's catchments, ranging from 2% for large dry catchments (e.g. Mundaring) to 19% for smaller high rainfall catchments (e.g. Stirling) and is 13% for Wungong Catchment.

Batini et al. (1980) showed an increase of 6 mm of streamflow for each one per cent of the area affected by dieback. Similar studies for bauxite mining show the increase in streamflow resulting from clearing and mining, and the decrease following rehabilitation (Croton et al., 2004). However, the influence of dieback disease on yield is very long-term whereas rehabilitation of bauxite pits means that the increase in water yield is transient.

Table 3 Factors controlling transpiration

Climate and weather	Local conditions	Tree physiology
● Light ● Rainfall ● Potential evaporation ● Temperature ● Humidity ● Wind	● Topography ● Soil type and geology ● Soil moisture and quality	● Roots ● Conducting material ● Leaf area ● Stomata

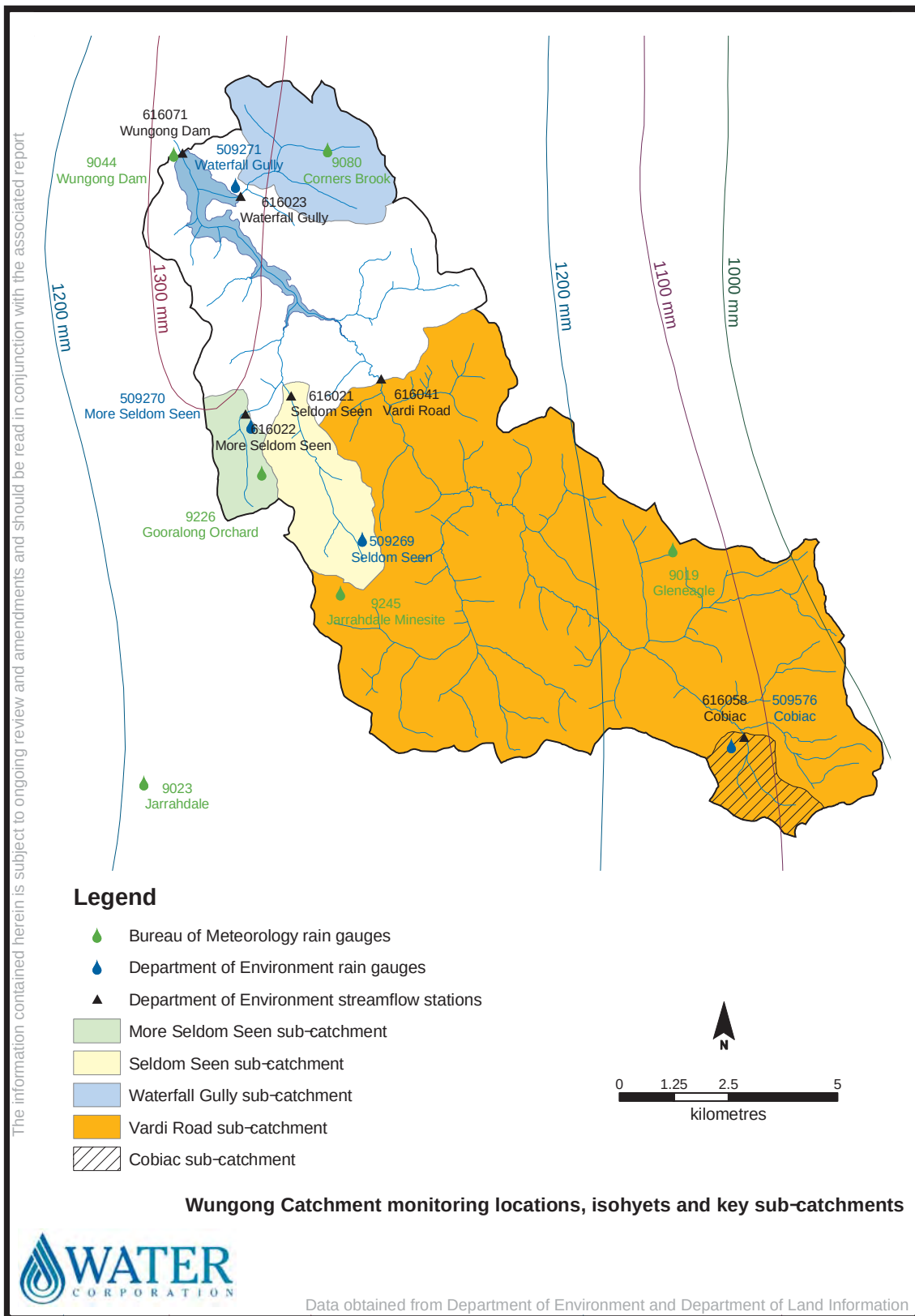


Figure 11 Wungong Catchment monitoring locations (note: isohyets are based on 30 years to 1981, and are used for salt risk assessment)

There are now an additional 30 years of rainfall, run-off, land-use and water quality data available that has been analysed (Bari and Ruprecht, 2003). Work is ongoing and monitoring will continue so as to record the effects of the proposed treatments. Past research with catchment thinning to a similar basal area as that being proposed for the Wungong Catchment is shown in Figure 13 (although this was a once off thinning without the follow-up management planned in the Wungong Catchment Management project) and therefore shows a decay in water yield after about five years – returning to pre-thinning flows by 12 years (Bari and Ruprecht, 2003).

The effects of changes in land-use are often confounded by climatic trends, although the climate of south-western Australia was considered strongly seasonal and predictable (Gentili, 1989). More recently the forested catchments in Western Australia are undergoing a severe drying trend. Whereas the annual water yield from the IWSS surface catchments during the 1911–1974 period has been 338 GL, the average yield during 1975–1996 was 177 GL, and during 1997–2003 it was only 121 GL. The 2001 and 2002 water years averaged only 64 GL, which is the lowest two-year average on record.

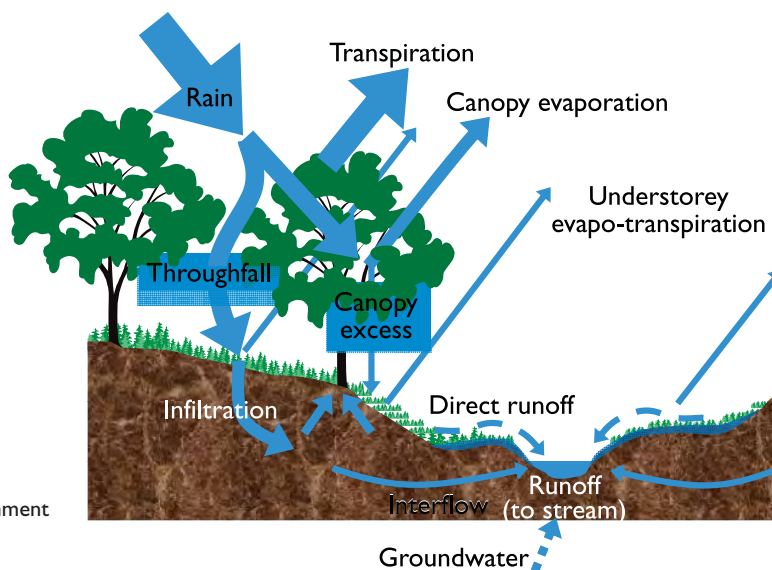


Figure 12 Run-off in a forested catchment

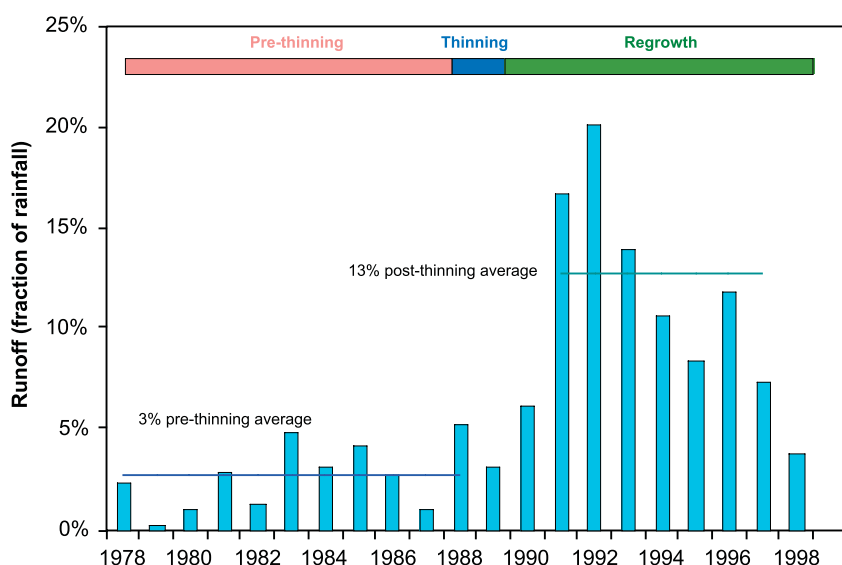


Figure 13 Increase in water yield by thinning from 37 to 15 m²/ha (Higgins Catchment north of Dwellingup with 1190 mm average rainfall during study)



4.4 Climate change

4.4.1 Rainfall changes

Climate changes on many timescales from inter-annual to multi-decadal, and is caused by a range of factors from natural to anthropogenic. While the most topical cause for climate change is the enhanced greenhouse effect, natural variability has probably had as large an impact on the rainfall in south-west of WA for the past three decades. Climate change is not just something that may occur in the future, it is something the south-west of WA has, and will continue to experience. Jarrahdale annual rainfall shows the obvious inter-annual and multi-decadal variability, with a 15% reduction in 1975 and it seems another 8% step down after 1996 (Figure 14).

The graph plots total annual rainfall in millimetres (mm) at Jarrahdale against the water year. The Jarrahdale Station is representative of the rainfall in the forested catchments around Perth, including the Wungong Catchment. The water year is taken from May to April, and the labelled year is the beginning (winter) year. Plotted over the annual totals (as columns) there are horizontal lines, which are averages of annual rainfall for the period the line covers.

As can be seen from Figure 14, the annual rainfall has stepped up and down in the past. The change around 1975 was widespread across the south-west of WA (including at Rottnest Island which is outside the influence of land-use changes and local industry on the mainland), and at the same time there were changes around the hemisphere. The rainfall change around 1975 was characterised not just in a reduction in annual total rainfall, but in

- ◆ less rain days;
- ◆ less rain in wet years; and
- ◆ winter starting and peaking later (i.e. summer running longer).

The causes for the change are thought to be mainly natural variability, but with some possible component of enhanced greenhouse effect. Investigations on this climate system are being undertaken by the Indian Ocean Climate Initiative (IOCI, 2002).

Rainfall is a key driver for the environment and our water resources. The aquatic and terrestrial ecosystem is reliant on rainfall. After 1996 the rainfall is lower than the post-1975 average. This period of lower rainfall after 1996 has been observed in south-eastern Australian states as well.

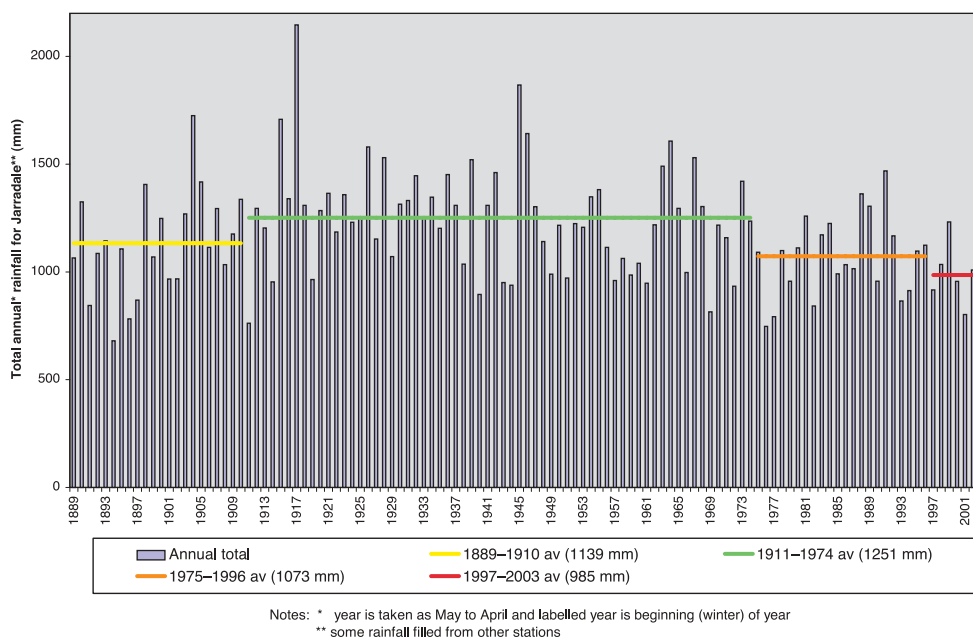


Figure 14 Jarrahdale annual rainfall (1889–2003)

4.4.2 Streamflow changes

The IWSS's annual streamflow amplifies changes in rainfall with a 50% reduction after 1975 (Figure 15). The graph plots total annual streamflow in millions of kilolitres (gigalitres) to all of the current IWSS reservoirs as if they were always built (excluding sources from Stirling Reservoir onwards) against the water year. The water year is taken from May to April, and labelled year is beginning (winter) of year. Calibrated hydrological catchment models are used to generate streamflows into reservoirs for the years where they did not have stream gauging.

The hydrology of our streams is sensitive to the timing and amounts of rainfall (mainly during winter with our Mediterranean climate). The decrease in rainfall around 1975 has led to a much greater decrease in streamflow. While land-use is also important for streamflow, there were no large-scale changes in catchment land-use in the mid-seventies that could have been the primary cause for the streamflow decrease.

Streamflow is important not just for our water supplies, but for the aquatic ecosystem. In more recent years, in particular the 2001–2002 drought, some streams that flowed every winter (in remembered history) have stopped flowing.

Decreases in streamflow mean there is not as much water for our IWSS reservoirs. After the Water Corporation was formed in 1996, over half a billion dollars were spent in recovering the supply-demand balance due to the 1975 climate shift to a drier regime. After 1996 the streamflows have been reduced below the post-1975 average, and it seems the climate regime may have shifted again post-1996 to something even drier. Using enhanced greenhouse gas climate projections, streamflows in the Stirling Catchment were projected to reduce by 31% due to an 11% reduction in rainfall (Berti et al., 2004). This century is expected to be hotter and drier than last century. Uncertainty about the future climate and continued growth means that while demand will be managed, new water sources are required.

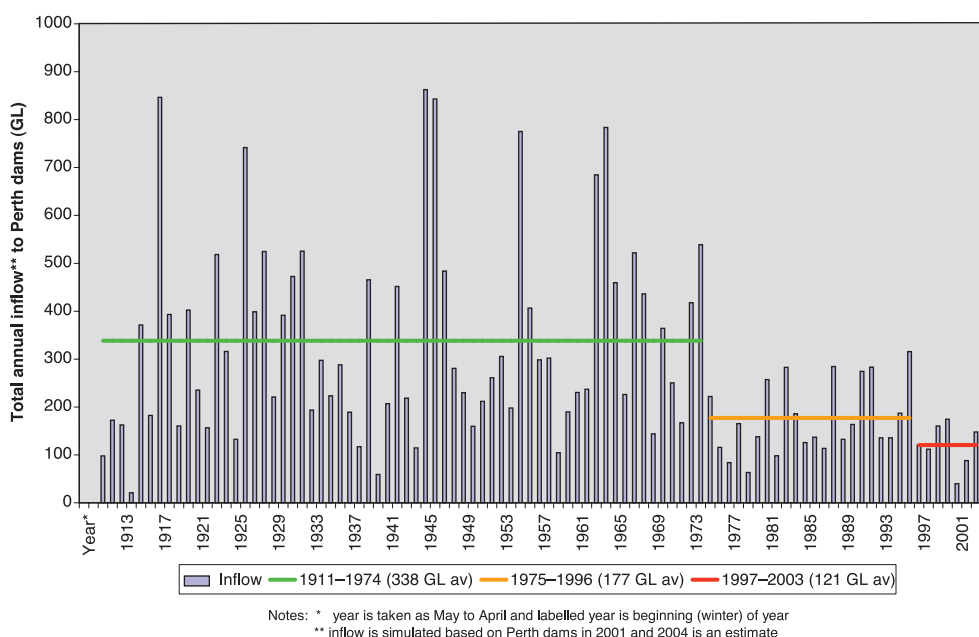


Figure 15 Annual streamflow to all Perth dams (1911–2004)



4.4.3 Impact of further rainfall reduction on catchment management

If future rainfall is lower than the current climate this will have further impact on our environment and water resources. Studies are under way by CALM and DoE looking at the impact on these two areas (e.g. Berti et al., 2004). The expectation is that lower rainfall will have an adverse impact on biodiversity, including the aquatic ecosystem, and therefore lead to a degradation of the environment in the south-west of WA and a reduction in the water resource.

Underlying an important part of this project is the water benefit obtained from catchment thinning. If rainfall reduces further, the increase in streamflow due to the project will not be as large as expected. Under some rainfall scenarios the thinning would maintain the current streamflows, not increase them. Although having an adaptive management framework will allow for adjustment to prescriptions based on feedback from monitoring and research. The adjustments would be for environmental or water benefits.

Even if the extra streamflow produced by this project was only one third of what is currently expected, this will still be at a lower cost per kilolitre than the average water source development cost.

4.5 Drinking water quality

Although our drinking water catchments have been disturbed by a range of land-uses they are still forested catchments that produce high quality drinking water. Water quality in the main stream flowing into Wungong Reservoir is monitored by Water Corporation in accordance with Australian Drinking Water Guidelines (NHMRC and ARMCANZ, 1996).

All water quality parameters for Wungong Dam outflow water meet the health requirements of the National Health and Medical Research Council's (NHMRC) guidelines. Occasionally, the pH, turbidity, iron, manganese, aluminium and nitrate levels in the Wungong Reservoir have exceeded the NHMRC aesthetic guidelines. When this occurs the reservoir can be rested until the quality recovers naturally. The levels of the remaining aesthetic related parameters monitored in the reservoir are within the acceptable limits. The water abstracted from the Wungong Dam is disinfected by chlorination, and fluoridated, before supplying the IWSS. Chlorination is an essential barrier used to ensure good quality public drinking water (NHMRC & ARMCANZ, 1996).

Although reservoir storage and disinfection by chlorination generally removes microbiological contamination, treatment processes alone cannot be relied upon. Contamination can and should be prevented or reduced through appropriate land-use or activity controls in the catchment area. This approach is endorsed by the Australian Drinking Water Guidelines, and reflects a 'catchment to consumer' multiple barrier approach for the provision of safe drinking water to consumers.

4.6 Recreation and tourism

Several recreational activities currently occur in the Wungong Catchment. Approved recreation activities include bike riding on the Munda Biddi trail, camping at the Munda Biddi campsite and the Darling 200 motor rally event.

In the past, the annual Darling 200 motor rally has been staged in Gleneagle State Forest under the direction of the Confederation of Australian Motor Sports. For any existing events, an environmental management plan must be submitted and must meet the requirements of Water Corporation, DoE and CALM.

The Munda Biddi Trail is a long-distance mountain-bike trail, and part of this trail passes through the south-eastern part of the catchment. The trail lies outside the Reservoir Protection Zone (RPZ) and no part of the bike trail and access tracks are allowed within 50 m of a watercourse. The trail is expected to attract approximately 10 000 cyclists annually, of which some proportion will pass through this area. CALM and Friends of the Munda Biddi Trail will manage the Munda Biddi Trail. A campsite, easily accessible from the Munda Biddi Trail has been built north of Jarrahdale Road and west of Albany Highway, near the Wungong Brook. CALM and Friends of the Munda Biddi bike trail manage the campsite.

There is a short trail to a lookout in the RPZ. Water Corporation rangers regularly visit this lookout to ensure it is maintained. Below the dam wall are picnic facilities and parking.

An archery club and a shooting range are located inside the catchment. These operate a few days per week, with the majority of the usage on weekends.

The DoE undertake water source protection planning, which is a consultative process and follows a 'catchment to consumer' approach, to manage water quality in drinking water catchments. The DoE have initiated this process for the Wungong Catchment.



5 Project descriptions

5.1 Outline

This project is designed to confirm the hypothesis that active management of dense regrowth forest can produce good environmental, water quality and water quantity outcomes. The experiment involves on-ground activities being managed in an adaptive framework. The project is a package of catchment management activities: targeted catchment thinning of small mostly non-commercial trees, staged conversion of exotic species to natives, monitoring, research, independent auditing, reporting, consultation and projects for additional environmental benefit.

The project is based on current best-practice silvicultural, hygiene and safety requirements relating to management on water supply catchments. The current CALM silvicultural guidelines include provisions for the retention of buffers, of habitat and of understorey diversity. Standard CALM dieback hygiene practices are proposed. The application of herbicides will follow the standard procedures contained in CALM's Herbicides and Chemical Users' Manuals, as well as the Pesticides Advisory Committee's recommendations (see Section 6.2.2). Any commercial logging operations will be conducted by FPC in accordance with the approved Forest Management Plan 2004–2013 and their published codes of practice, Contractor's Timber Harvesting Manual, silvicultural prescriptions and control systems. Prescribed burning for biodiversity management, hazard reduction or for establishment or regeneration will be carried out by CALM in accordance with current procedures, established over many decades of experience and with any proposed changes arising from the EPA's current review of CALM's policies and prescriptions.

Detailed prescription plans for on-ground activities within the entire catchment will be developed when approval is given, with those proposed for treatment area number one shown in Section 5.5. The prescriptions explain the on-ground activities to be carried out, their location and timing.

These plans will evolve as more is learnt about the environmental and water response to work completed. Figure 16 gives an overview of the mosaic of forest areas within the 12 845 ha Wungong Catchment, which provides a starting point for developing detailed prescriptions.

The general prescriptions are explained in successive sections, and are developed from the three main areas on Figure 16:

- ◆ **protected areas: no silviculture other than prescribed burning** – made up of defined protected areas as formal and informal reserves (including fauna habitat zones), reservoir buffer and experimental control sub-catchment (38% of catchment area);
- ◆ **silviculture in native regrowth forest**, some of which is open and will not require thinning, and some of which contains exotic species planted before 1988 as part of dieback rehabilitation and may need staged conversion back to native species (41% of catchment area); and
- ◆ **areas cleared and replanted following mining or pine plantations** where exotic species will be converted back to natives, and there will be thinning of mining rehabilitation after approvals are obtained from Alcoa, CALM and MMPLG (over mining rehabilitation) and negotiation with FPC (over pines) (up to 21% of catchment area).

It is expected that the thinning program will be introduced over a period of approximately 4–6 years. In addition to the three categories above, there will be areas that do not require thinning, but may require environmental enhancement (control of exotic species, reseeding or replanting).

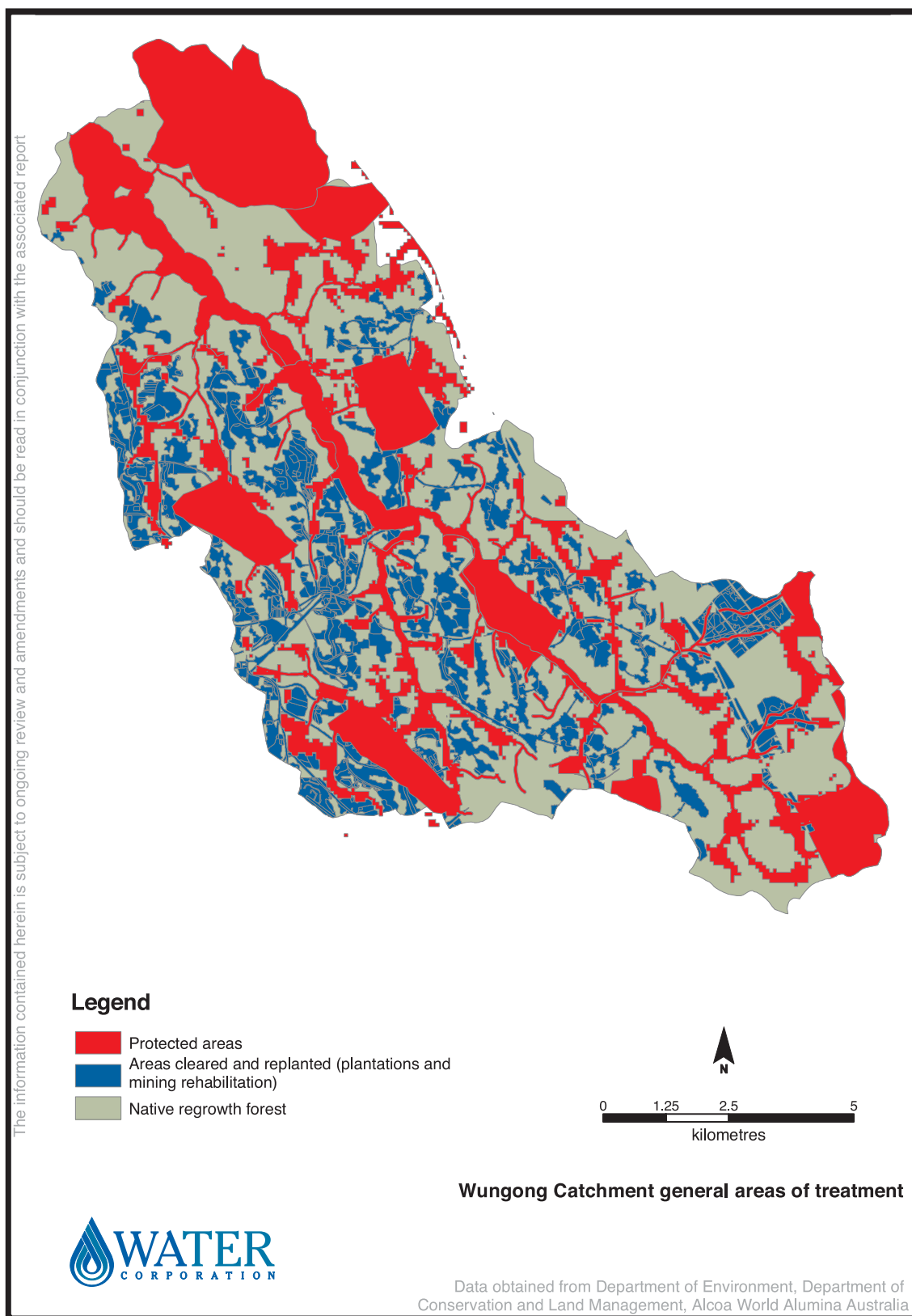


Figure 16 Overview map of general areas of treatment for the Wungong Catchment



5.2 Treatment categories

5.2.1 Environmental enhancement and prescribed burning

This category includes areas to be protected as well as areas that have been identified as not requiring any catchment thinning because they are too young or not over-dense (i.e. below 15 m²/ha) (Figure 17). Some areas that are not going to be thinned are within mining rehabilitation or native forest, and could be enhanced by seeding of native species and removal of exotics.

Figure 18 shows the areas to be protected and indicative fauna habitat zone. The protected areas include all areas identified as formal and informal reserves under the Forest Management Plan 2004–2013 (see Appendix 5: Summary of Informal Reserves). In addition, a 100 m buffer will be established around the reservoir where no disturbance is to occur (to protect water quality) and the Waterfall Gully sub-catchment on the northern side of Wungong Reservoir will also not be treated. This sub-catchment has been the hydrological control for past catchment trials and will continue in this role.

Previous studies in the jarrah forest recognise that the rocky and non-forest areas with their predominance of heath-like species are very important for biodiversity and in fact many restricted species are associated with these non-forest areas (Bell and Heddle, 1989; Mattiske and Havel, 1998) (Figure 19).

Furthermore, the riparian vegetation is very important fauna habitat (Nichols and Muir, 1989) (Figure 20). A total area of 300 ha of proposed National Park occurs in the upper reaches of the catchment. This area within the proposed National Park will not be impacted upon by the proposed thinning operations.

Maintenance of these undisturbed areas will be of value for biodiversity conservation, water quality and quantity, and aesthetic considerations. In addition, fauna habitat zones will be designed by CALM, in liaison with the Water Corporation and others, as foreshadowed in the Forest Management Plan 2004–2013, to supplement the other protected areas and to fit in with logical management boundaries, such as roads and tracks.

During all operations the key understorey species will be retained (Figure 21).



Figure 17 Open dieback forest with low shrub (about 6 m²/ha basal area) – not treated
(Photo by Jack Bradshaw)

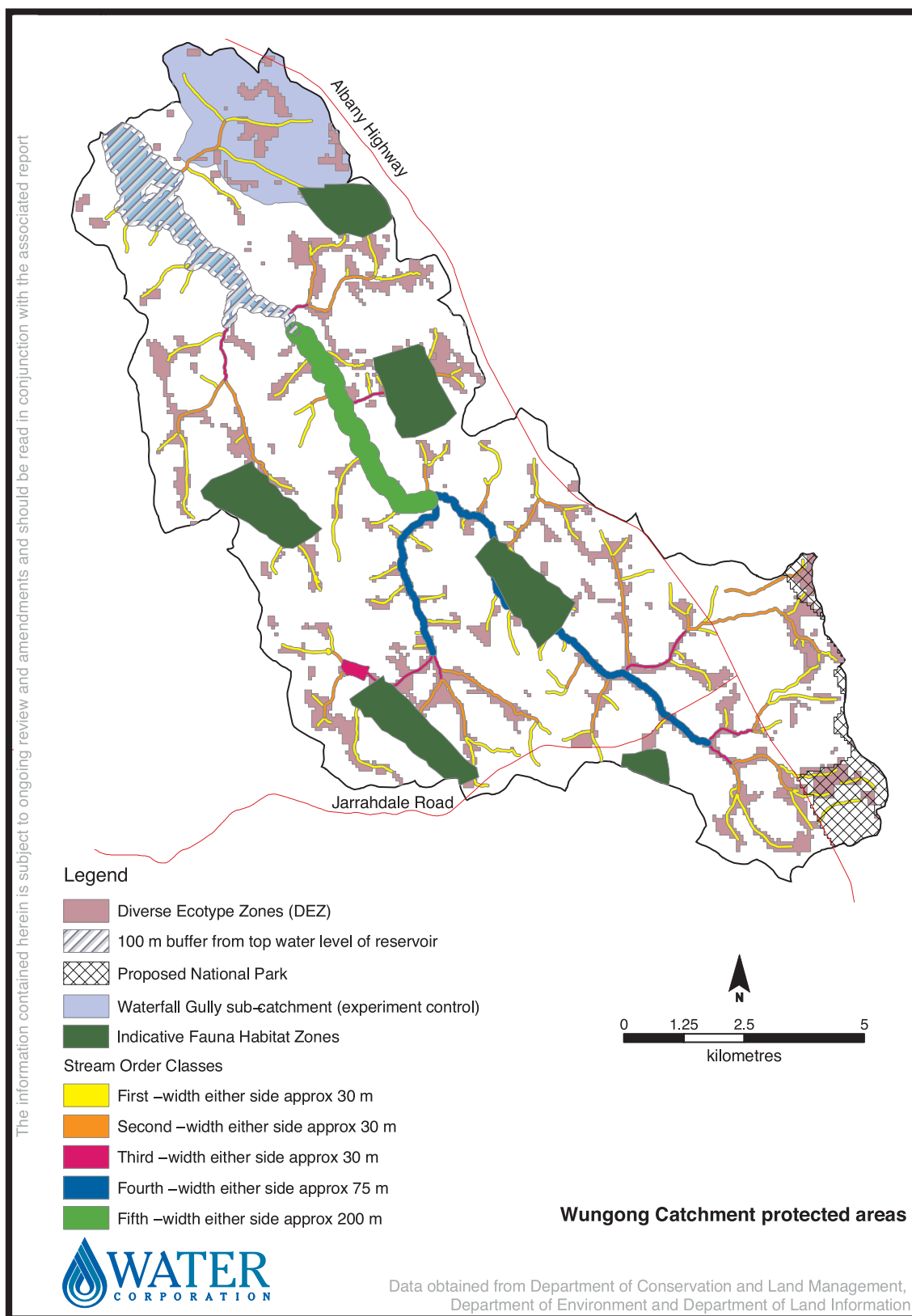


Figure 18 Protected areas in Wungong Catchment



Figure 19 Protection of rocky outcrop in Wungong Catchment (Photo by Colin Terry)

Figure 20 More Seldom Seen Creek and V-notch weir (Wungong Catchment) (Photo by Colin Terry)



Figure 21 Retention of key understorey species during thinning (Photos by Colin Terry)



5.2.2 Conversion of pine plantations and plots back to native forest

The Gleneagle pine plantations cover about 300 ha within the catchment and was clear-felled in summer 2004 by FPC and an evaluation of the most appropriate future land-use would be desirable (Figure 22). These plantations are a source of product for the FPC that is required to meet commitments to industry made by the State. The Water Corporation has had initial discussions with FPC and CALM to see if alternative mutually acceptable options for replanting pine are available elsewhere. Even if these discussions are not successful, the newly planted areas will have a low canopy density for several (5–7) years and the Water Corporation will continue to liaise with FPC over their future management.

Of this 300 ha within the catchment, about half is located near the former Gleneagle settlement and is of reasonable quality (Site Quality II and III) and could be replanted commercially. The balance is of lower quality (IV-V and Failed) and may not be desirable for replanting.

The project therefore could be a mixture of the removal of all commercial timber by FPC, the remaining pine could be burnt, protecting where possible any major elements of native flora (e.g. *Xanthorrhoea preissii* (balga)) that have survived and then the area could be scarified, sown to a mixture of native understorey and canopy species and fertilised. Consideration will also be needed towards controlling pine regeneration from seed. The areas where the pine has failed may simply require a hot fire to regenerate and favour native species.

Such treatments are expected to increase the area's values for biodiversity, for water yield and for aesthetics.



Figure 22 Gleneagle pine plantation in Wungong Catchment (Photo by Colin Terry)



5.2.3 Non-commercial thinning of native regrowth forest

The native jarrah forest that has been previously cut on one or more occasions is now regenerated to denser stands of jarrah regrowth, with basal areas upwards of 30 m²/ha (while the target basal area is 15–18 m²/ha, equivalent to a spacing of 5–6 m between trees) (Figure 23). These areas will include the denser stands of regrowth jarrah forest, whether or not these stands were treated under the Forest Improvement and Rehabilitation Scheme (FIRS) or Disease Forest Rehabilitation (DFR). Unlike karri that has an ability for self-thinning, the experience with jarrah regrowth is that these stands tend to compete very strongly and to lock-up and for growth rates to stagnate (Stoneman et al., 1989).

Thinning trials have demonstrated the capacity to dramatically increase both water and timber yields (Water and Rivers Commission, 1997; Stoneman et al., 1989, 1996; Bari and Ruprecht, 2003) and substantial areas of the jarrah forest have already been thinned. CALM data show that 9700 ha were non-commercially thinned in the 1998/1999 financial year, 10 300 ha during 1999/2000, and that 97 000 ha were thinned between 1985 and 2000.

To maintain these benefits periodic follow-up treatment of coppice will be required and the stands will need to be thinned again once the upper level of basal area has been exceeded. The proposed thinning schedule would be based on standard guidelines used by CALM, including Stream Buffer, Hygiene, Herbicides and Chemical Users Manuals and Silvicultural Guideline 1/95 (and any future amendments from the Forest Management Plan 2004–2013), where the recommendations for retained basal areas range between 10 and 18 m²/ha. However, in very dense stands (say greater than 30 m²/ha) it is proposed, for aesthetic reasons, to initially reduce these by no more than 50% of the existing basal area, with a follow-up treatment to 15 m²/ha possibly some 5–10 years later.

In addition, habitat trees will be retained within the 15 m²/ha and some of the larger specimens of understorey species such as balga, banksia and sheoak will be retained, either as isolated specimens or in groups. In a few areas, quite large pure stands of sheoak have been observed. These will be retained unthinned.

Stem-injection with herbicide (Figure 24) will be the preferred treatment with cut-stump (Figure 25) only used alongside burn boundaries, walk-trails, recreational sites, and major travel routes. Previous thinning provides a guide to what this could look like (Figure 26 to Figure 28). Diagrammatically, thinning is shown in Figure 29. Some five years after the first prescribed burn, treatment of stump coppice and advance-growth saplings with herbicide may be required. This would include managing any ‘wheat-field’ regeneration, and keeping species in a natural balance. Re-thinning of the overstorey will be desirable at about 15–20-year intervals.

The potential to encourage fewer but larger trees and a more open canopy may lead to slight changes in the local numbers of some herb, ground cover and understorey species (Stoneman et al., 1989 and Mattiske, E., *pers. comm.*). These slight changes are well within the range of natural fluctuations that occur on a local scale. Larger trees have bigger branches and when damaged these develop bigger hollows and at an earlier age, which is good for fauna habitat. Pile-sized stands (trees of 40–60 cm diameter trunks) that have been thinned exhibit some of the more desirable features of older-growth stands. This project will increase streamflow, and growth rates on the retained stems. It may also have long-term benefits for terrestrial and aquatic biodiversity by providing more water during a climatic drying cycle and in the longer term for aesthetics.

The continuing selection of jarrah for sawlog over the past 100 years and dieback has altered the natural balance to favour marri. However the retention of a greater proportion of marri trees in the mix is favoured as they are resistant to dieback disease, produce a good honey and their seeds are useful for birds such as cockatoos. Marri is also less rot resistant, so more readily develops stem hollows for fauna.

The Water Corporation has accessed the research and silvicultural data that are already available and proposes

strict adaptive management whereby research and monitoring of treated areas is also carried out by independent organisations and where the data are made freely available for review. Treatments may then be adjusted as required, or cease if the serious negative effects cannot be ameliorated. The Conservation Commission of WA has identified the need for research into the environmental and water impacts associated with varying the target basal area (Section 1.7.1). It is proposed that this will be undertaken within the native regrowth forest and the bauxite mining rehabilitation planted to native species.



Figure 23 Dense jarrah forest with low shrub (about 24 m²/ha basal area) – could be thinned (Wungong Catchment)
(Photo by Jack Bradshaw)

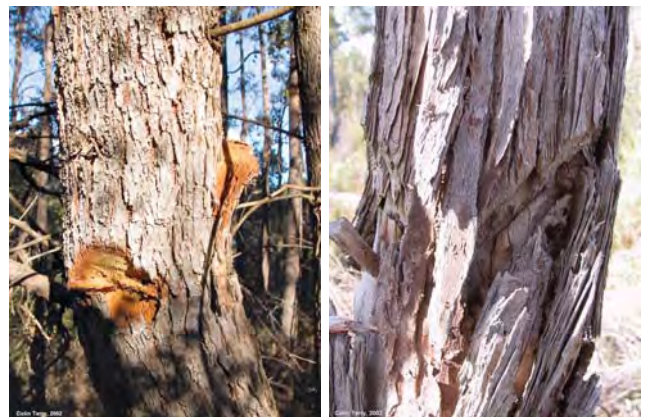


Figure 24 Detail of stem-injection showing notches in tree stem (recent and older operations)) (Photos by Colin Terry)



Figure 25 Detail of cut-stump operation (operator felling tree and spraying with herbicide) (Photos by Carl Grant, Alcoa World Alumina Australia)





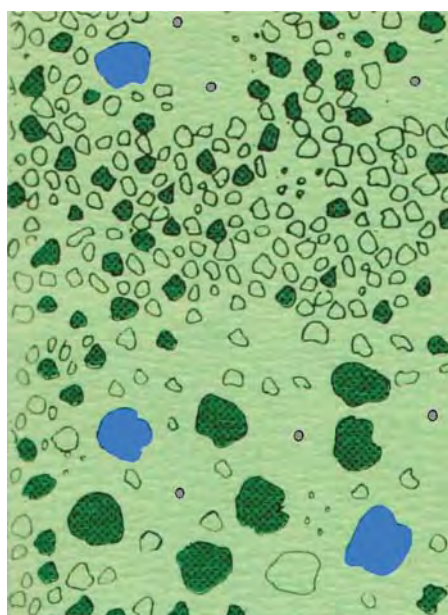
Figure 26 Regrowth forest thinned in 1989 trial from 37 to 15 m²/ha (Higgins Catchment) (Photo by Colin Terry)



Figure 28 Forests Department (now CALM) thinning trial at Inglehope by cut-stump in 1960s (Photo by Colin Terry)



Figure 27 Thinning by stem-injection in Hansens Catchment in 1985/86 (Photo by Colin Terry)



(a) Before



(b) After

Legend

-  Thinning
-  Potential crop tree
-  Stump
-  Cull tree
-  Primary and secondary habitat trees

Figure 29 Plan view of typical native forest showing changes due to non-commercial thinning (adapted from Bradshaw, 1987)

5.2.4 Thinning of bauxite mining rehabilitation planted to exotic species

Data provided by Alcoa show that bauxite mining rehabilitation planted to exotic species covers about 1100 ha in this catchment. The earlier sites were established with little understorey cover (Figure 30), but in the latter years native understorey species were introduced into the seed mix (Bartle and Slessar, 1989). The exotic trees on some of these sites have potential to be commercial for sawlogs, for mixed chiplogs and for fuelwood and will be offered for sale by the FPC. Non-saleable stems that require thinning will then be injected with herbicide.

Experience has shown that some of the eastern States eucalypts (such as *E. resinifera*) have very high seed reserves and regenerate very strongly after fire, leading to potential weed problems. Data collected by Alcoa show that differences in regeneration potential is dependent both on the season and the intensity of the burn, with more native species and fewer exotics regenerating during milder spring burns (Grant et al., 1998).

The intention in these sites is to increase the native understorey species cover and diversity and to gradually convert the overstorey species from exotics to native eucalypts. Adaptive trials will be conducted to test several silvicultural techniques, including burning, scarifying, seeding (rates up to five times the normal rate of 500 g/ha could be required, Grant, C., *pers. comm.*) and fertiliser application. Because of the strong seeding potential of some of the exotic species, it may not be possible to achieve this change in one treatment. Specific control of unwanted regeneration of exotic eucalypts over long time periods may well be required.

It is expected that these treatments will enhance the site's value for water yield, biodiversity and aesthetics. Agreement by CALM, the MMPLG and Alcoa will be required.



Figure 30 Twenty-year-old exotic rehabilitation with low shrub (about 36 m²/ha basal area) – could be thinned
(Photo by Jack Bradshaw)



Figure 31 Alcoa exotic rehabilitation thinning, Banksiadale sub-catchments of South Dandalup Catchment
(Photo by Colin Terry)



5.2.5 Treatment of dieback rehabilitation sites planted to exotic species

Some dieback areas were formally replanted by the Forests Department to pine species or exotic eucalypts, with no seeding of understorey species. Other dieback areas have been treated and seeded by Alcoa as part of their Dieback Forest Rehabilitation commitments. The jointly agreed objectives and prescriptions are contained in CALM-Alcoa Working Arrangements.

The project would aim to gradually convert these areas back to a native species, both over and understorey, either by clearing and re-establishment of the site or by repeated, selective removal of the non-native components and seeding with natives.

This treatment is expected to increase the value of these sites for biodiversity, for water yield and for aesthetics.

5.2.6 Thinning of bauxite mining rehabilitation sites planted to native species

Since 1988, the bauxite areas mined by Alcoa have been rehabilitated to native species. The predominantly jarrah overstorey has grown well and established dense stands that tend to suppress the development of understorey species. In addition, without any thinning it is quite possible that deaths of jarrah from drought may occur on the densely stocked sites. It is expected that both jarrah and understorey species will benefit from thinning.

Glen Samsa (2002) measured density and growth on eight sites aged between 10.5 and 12.5 years that were rehabilitated to jarrah.

The variation between sites was considerable, with stems numbers ranging from 726 to 2805 and basal areas over-bark from 6.5 to 29.2 m²/ha. If data for the best 200 crop trees is averaged and compared between these sites, the over-bark diameters ranged between 13 cm and 17 cm, the bole length between 5.6 m and 8 m, and total height between 9 m and 12 m.

The older jarrah planted on mine pits are now over 20 years old. These trees were between 26 m and 28 m high and diameters ranged between 23 cm and 35 cm. Some of this material may be saleable as sawlogs and mixed chip. Spacing trials conducted by Alcoa show that at age 13, jarrah seedlings planted at 625 stems/ha averaged 21 cm in diameter whereas those planted at 2500 stems/ha averaged 14 cm.

Some thinning trials have been carried out by Alcoa in four mine pits where the rehabilitated stands were 10 to 13 years old, both at Huntly and within the Wungong Catchment (Grant, C., *pers. comm.*). The trial involved pulling whole trees (too costly), felling and treating the stump with herbicide (this has to be done within 1–2 minutes of thinning and is also costly) and by stem injection (the lowest cost effective treatment). Scrub-rolling by skidder or loader and/or the creation of out-rows was necessary to create access in some dense stands. The rip-lines caused some problems with the stability of equipment. It may be necessary to modify existing logging equipment if larger scale operations are approved in the future.

In these stands, the existing stand density averaged 1750 stems/ha and this stocking rate was reduced by a light (1111 stems/ha retained), moderate (625 stems/ha retained) and a heavy (400 stems/ha retained) thinning treatment. In addition, two burning treatments (autumn and spring burning at different soil dryness index (SDI) levels) and two fertiliser treatments (500 kg/ha diammonium phosphate) were undertaken.

Basal areas averaged 34 m²/ha prior to treatment and 18.0, 12.5 and 7.5 m²/ha after the thinning. Prescribed fire after thinning is essential to reduce the fuel load on the ground, but should be carried out at SDI of below 600 to minimise scorch and damage to retained stems.

If the stands were thinned more regularly to about 660 stems/ha at 10–13 years of age and were maintained at about 15 m²/ha by periodic thinning and control of eucalypt coppice, the balance between wood production and water would be facilitated. If the stands were maintained above 20 m²/ha there is evidence from Stoneman et al. (1996) that the stand would suffer some water stress and there would be reduced run-off. The Wungong trial provides an opportunity to incorporate silvicultural practices that lead to high quality wood production as well as water for the population of Perth. This balance is required and the community needs to be aware of the costs of not undertaking these trials. As these stands mature, there is also the opportunity to allow some of the eucalypt coppice or advance growth to be released, so that an uneven aged eucalypt stand will develop. The Conservation Commission of WA has identified the need for research into the environmental and water impacts associated with varying the target basal area (Section 1.7.1). It is proposed that this will be undertaken within the native regrowth forest and the bauxite mining rehabilitation planted to native species.

Where stand density is such that thinning is not required, some scrub-rolling of mature undergrowth with machines may be considered, under summer dry-soil conditions, in order to minimise wildfire damage, to allow prescribed burning, and enhance development of herb and ground cover species.

This treatment of mining rehabilitation is expected to enhance the growth and diversity of understorey species, to minimise the risk of severe wildfire damage to the rehabilitated areas and to improve both water and timber yields.

All mining rehabilitation in the Wungong Catchment is still the responsibility of Alcoa until it is handed back to the State. The MMPLG has agreed on the completion criteria, but the State has not signed off on any of the areas rehabilitated. Until there is agreement between Alcoa, CALM and the MMPLG, no thinning by the Water Corporation can take place.



Figure 32 Alcoa rehabilitation thinning trial in South Dandalup Catchment (to basal area – 13 m²/ha, about 625 stems/ha) (Photo by Colin Terry)

5.3 Liaison over management by others

5.3.1 Liaison over areas proposed to be commercially logged by FPC

The Water Corporation has liaised with both FPC and CALM over areas proposed to be logged commercially over the next 15 years. The logging plans are still being developed by CALM. Utilisation of the wood resource would be desirable, but it's up to FPC to develop markets and uses. Many of these areas in the Wungong Catchment have been logged heavily in the past and the remaining saleable sawlog volumes may be too low for commercial operations. Also, local communities have recently expressed concern about several logging proposals in the 'hills areas' near Perth. The FPC and CALM will obtain the required approvals for any operations separately from this project.



Any commercial logging will be conducted in accordance with procedures required in the approved Forest Management Plan 2004–2013 and documented in the Contractors' Timber Harvesting Manual (FPC, 2003).

It is always preferable for proposed thinning to follow commercial logging operations and the Water Corporation will maintain liaison with the FPC to ensure that this is done. In addition, it may be desirable for the FPC fallers to immediately treat with herbicide the stumps of the felled trees, so as to reduce the cost of future treatment of the coppice. Where this is required, a suitable financial arrangement will be negotiated between the faller, the FPC and the Water Corporation. Where scrub-rolling will be required by FPC, larger individuals and patches of key understorey species such as balga, *Persoonia*, sheoak and large banksia will be retained, according to the requirements of the jarrah silviculture guideline.

5.3.2 Liaison over areas that are proposed for prescribed burning

It is expected that CALM will continue with standard prescribed burning operations on this catchment for hazard reduction and for protection of life and of key property assets (example burn in Figure 33). Some additional burning may be required specifically for this project in order to rehabilitate some areas (e.g. pine plantations, exotic eucalypts), for regeneration (e.g. dieback areas) or for removal of 'slash or tops' after thinning.

Any such burns will be implemented by CALM in accordance with the procedures that have been developed over at least 40 years of experience and that are comprehensively documented in the CALM Fire Operations Manual. Burns will be carried out on low SDI, less than 600, on a falling hazard (e.g. in late afternoon), and possibly during any dry periods in winter months.

Within rehabilitated bauxite stands, the susceptibility to fire changes with age (Smith, 2001). There is a

relatively low risk to the stand between 5 and 8 years, then a very high risk due to the large quantity of well-aerated fuels. This understorey gradually collapses (which can be hastened by scrub-rolling) until low intensity fires can be introduced, which occurs at approximately age 15.

If the bulk of the thinning is carried out by stem injection, leaf-fall will occur but the stem will remain upright as a 'stag'. This means that much less fuel will be available on the ground and it will allow milder burns to be carried out for hazard reduction. However, the dead stems may look unsightly and may ignite and lead to 'hop-overs' during a burn. For these reasons, thinning by falling (cut-stump) is favoured near areas with public use and for at least 30–50 m around existing or proposed burn boundaries (depending on the height and age of the stands). This leads to a greater accumulation of fuels on the ground in these areas. The burning prescription will need to take these matters into account, to avoid a burn that severely damages the retained stems (see Section 5.5.1). In addition, retained stems will need protection by the implementation of appropriate 'crop tree protection' practices.



Figure 33 Department of Conservation and Land Management mild burn in Wilson Block (Photo by Colin Terry)

5.4 Differences between non-commercial thinning and commercial logging operations

Forest harvesting practice is usually carried out in two parts – commercial logging followed by the non-commercial removal by herbicide application of those trees that cannot be sold as a commercial product (Bradshaw, 1987). Commercial logging in State forest is provided for by the Forest Management Plan 2004–2013 and is carried out under strict controls to achieve stated silvicultural objectives. This project focuses on non-commercial thinning, with potential for limited commercial logging in some of the older mining rehabilitation.

The basic principles of silviculture in the jarrah forest are:

- ◆ To promote growth, by thinning the forest. This is favoured, so as to enhance growth rates on retained crop trees. Usually applicable in heavily cut-over forest or areas treated prior to 1940. Often in pole stands with less than 20% density in the upper stratum. Retain basal areas of between 10 m²/ha (at 25 cm diameter) and 20 m²/ha (at 50 cm diameter).
- ◆ To release regeneration by creating gaps, where there are too few crop trees to warrant thinning, but where there is adequate coppice and saplings present. These include fire-damaged stands, virgin bush and post-1940 areas with light selection cutting. Also massed stands and pole stands with greater than 30% density in the upper stratum. Gaps range from two to four times tree height, from less than 1 ha to a maximum of 10 ha.
- ◆ To establish regeneration by shelterwood cutting, where crop tree stocking is inadequate and there is insufficient coppice. Often these are virgin forest or areas with dense sheoak and banksia understorey, especially in Havel types P and S. Trees are marked to retain a basal area of 10–15 m²/ha in the high rainfall zone.

The first task in treemarking is to determine the appropriate silvicultural objective. The process to achieve this has been described by Bradshaw (1987). All jarrah stands are treemarked, usually for retention, before harvesting. The forest is a complex mosaic with different structure and condition so that a fixed prescription would not be appropriate. Rather, the treemarking-silviculturist will apply the basic principles of silviculture to achieve one of the silvicultural objectives on each site. Across a larger area of forest, a mosaic of thinning, gap creation and shelterwood prescriptions will result.

Within the treemarked area, primary and potential crop trees are retained as well as ground habitat logs and stumps. Major understorey species such as balga, sheoak and banksia are also protected. Crop-tree protection is also carried out prior to the tops disposal/regeneration prescribed burn.

5.4.1 Commercial logging operations in native forest

Any commercial logging will be conducted in accordance with procedures required in the approved Forest Management Plan 2004–2013 and documented in the Contractors' Timber Harvesting Manual (FPC, 2003). Silvicultural practices used to harvest forests commercially include thinning, single tree selection, shelterwood, and the creation of gaps for regeneration that may range in size from a width equivalent of twice the average height of surrounding trees, up to an area of 10 ha. Habitat trees are retained throughout all of the above (Bradshaw, 1999). Standard guidelines also make provision for the protection of a representation of the larger key understorey such as banksia, sheoak and balga. The trees to be retained are marked beforehand according to the silvicultural objective required. This marking indicates the trees that must be protected and retained for both the commercial operation and the follow-up non-commercial operation.



This component of the operation requires the use of mechanised equipment and there is some soil disturbance associated with snig tracks (where felled trees are dragged) and landings (where felled trees are temporarily stored). Soil compaction and the risk of dieback spread are minimised by confining the operations to dry soil conditions. Under moist soil conditions, compaction and mixing of soil can occur. A substantial road network is required to remove the products. Commercial operations are targeted primarily at trees suitable for sawlogs that have a minimum size and quality requirement. The larger trees are usually targeted for removal and these may well provide bigger hollows and the better habitat for some species of fauna. With larger gaps (approximately 10 ha), a fragmentation of the habitat occurs.

5.4.2 Non-commercial thinning of native forests by stem-injection or cut-stump

Non-commercial follow-up treatment routinely occurs in harvested stands. Routine non-commercial thinning operations for timber production purposes are confined to the culling of all trees within 4 m of the selected 'crop' trees. Thinning for water will need to be applied more widely in the areas suitable for thinning (i.e. beyond the 4 m from the crop tree).

The culling operation is generally carried out on foot, and access for light vehicles only is needed. It involves the stem-injection of herbicide into a notch cut into the unwanted standing tree ('stem-injection') or the application of herbicide to the stump of a felled tree ('cut-stump'). Herbicide injection is not effective in dry atmospheric conditions which generally means it cannot be carried out in the summer months. Access to dieback free areas even for light vehicles in other periods of the year will require appropriate controls to avoid soil movement.

There is no soil compaction and minimal risk of introducing dieback disease. Each small non-commercial tree is individually selected for stem-injection or cut-stump; the larger, mature and more desirable habitat trees, the larger understorey species (e.g. banksia and sheoak), and the shrub and ground-cover species are not damaged (cut-stump may cause a somewhat higher, but small level of damage during felling). The forest structure is retained and there is no physical fragmentation of habitat.

5.4.3 Assessment of project's intensity of land management

At a presentation to CALM and Conservation Commission on 4 September 2003, the Chairman of the Conservation Commission queried whether the Water Corporation's project for catchment management in the Wungong Catchment was an intensification of land management.

The project is a package of catchment management, which includes catchment thinning of 62% of the 12 845 ha catchment during a 12-year research trial. Of this area, approximately 5100 ha will be from the native regrowth forest, although it is expected that some of this forest will already be open enough to not require thinning. A detailed silvicultural plan for the entire catchment is yet to be created, but as can be seen from Figure 16, the possible area for treatment is relatively fragmented.

The intensity of land management for the Wungong project compared to other disturbances was assessed through a quantitative and qualitative assessment. In lieu of a more substantial environmental risk analysis, three measures on intensity were used: area (where), timing (when) and impact from disturbances (what). The comparisons were made against four silviculture baselines with a summary shown in Table 4.

Table 4 Is Wungong project more intense than four baselines?

Baseline	Description	More intense?
Up to 1990	There are many historical precedents that were much more severe than the Wungong project, eg. large scale uncontrolled cutting up to 1920, sustenance stand improvement during the depression years and wildfires, which are far more intensive than the project.	No
1990–2001	The Wungong project was assessed as being less intensive than recent past silviculture. In particular, the Wungong project had a similar area treated per year and higher basal area retention than five harvest areas of similar size to the catchment. The individual areas treated under the Wungong project were smaller, and there was more uniformity from year to year in the area treated.	No
2004–2013	Compared to the expected silviculture under the Forest Management Plan 2004–2013, the Wungong project will treat more area per year than a single harvest area, but uses treatments that retain more trees (or higher basal area).	Unsure
Beyond 2013	Beyond the current forest management plan, silvicultural treatments (such as thinning) could treat at least as much area per year as the project to about the same basal area.	Unsure

In general, it appears the Wungong project is similar to or less intensive than past or future silviculture.

When considering the precautionary principle with respect to drought stress, fire risk and reduced stream flows, the 12-year Wungong project would benefit the Forest Management Plan 2004–2013 as an adaptive management trial. This will improve the understanding of forest management, and provide sound data on which to base the next forest management plan.

5.5 Sample prescriptions

In discussions with CALM and the Conservation Commission, the Water Corporation was asked to provide a detailed example of the prescriptions to be used in the project.

Prescriptions were developed for treatment area 1 (location shown in Figure 34). The distribution of treatment types for this area is shown in Figure 35.

5.5.1 Prescriptions for treatment area 1

5.5.1.1 No silviculture other than prescribed burning

Objectives

1. To retain an understorey and shrub layer in the streamzone to favour fauna (e.g. quokka) and protect stream water quality.
2. To retain habitat trees, diverse ecotypes and fauna habitats.
3. To reduce thinning cost by avoiding non-dense areas.



Prescription

1. No logging or non-commercial thinning will be carried out in this category.
2. Prescribed burning of the streamzone vegetation will be done by CALM in accordance with a prescription aimed at maintaining and improving habitat.
3. The adjacent forest will be prescribed burnt by CALM in accordance with approved practice and rotation cycles.

5.5.1.2 Environmental enhancement

Objectives

1. To reduce the numbers of exotic and weedy species and replace them where possible with native flora.
2. To enhance ground and understorey flora by seeding where these are sparse.

Prescription

1. Where thinning is required, native crop trees will be favoured for retention.
2. Bare areas and those planted to exotics may be undersown with native understorey and overstorey species post logging and burning. Current data suggest that higher than normal seeding rates will be required for success (i.e. up to 2.5 kg/ha). Further trials are desirable.
3. The timing and intensity of prescribed burning should favour the germination of native species rather than exotics. Current data suggests that milder spring burns are the more favourable. Reducing soil disturbance, e.g. by notching, should also decrease unwanted germination.
4. Selective notching of weedy species (e.g. *Pinus pinaster*) or foliage spray of smaller weeds with an approved herbicide may be required.

5.5.1.3 Thinning of rehabilitated bauxite pits (exotic and native species between 10 and 30 years old)

Objectives

1. To thin to basal areas of between 15–18 m²/ha, so as to enhance streamflow, to use saleable forest produce, to encourage the development of native ground and understorey species and to enhance tree growth rates and crown health.

Prescription

1. Thin stands that contain commercial products to 15 m²/ha by the cut-stump technique ensuring that herbicide is immediately applied to the stump. Stockpile, remove and sell the produce where possible. Outcrops may be required for access. Carry out crop tree protection. In marking for retention, favour crop native overstorey species over exotics.
2. Thin stands that contain non-commercial products by stem-injection with herbicide.
3. Should small stands of exotic species be proposed for clear-felling (e.g. karri and *Eucalyptus globulus* for sawlog and chip), regenerate these areas to favour jarrah forest species. This may require particular burning prescriptions (usually in spring) so as to minimise germination of unwanted species, herbicide treatment of unwanted regrowth and sowing with native understorey and overstorey species (often at high rates, 2 to 2.5 kg/ha). Where stands of exotic species are thinned, trial the undersowing of these stands with seed of native jarrah forest species (2 to 2.5 kg/ha) after the burn.

4. Prescribe burn the thinned stands under conditions designed to minimise damage to the retained stems. Prescribed burning or scrub-rolling in advance of thinning may also be necessary in some cases to improve access (e.g. Fire Danger Index (FDI) 12–17 m/h, SDI less than 250, or late afternoon and evening burns as SDI is less than 600). These values are consistent with CALM guidelines for a first burn under regeneration.

5.5.1.4 *Silviculture in jarrah regrowth stands*

Objectives

1. To identify the silvicultural need for each stand (establish regeneration, release regeneration or promote growth) and then apply the appropriate silvicultural treatment – shelterwood, gap creation or thinning.
2. Follow up with non-commercial thinning when required.

Prescription

1. Implement the recently revised Jarrah Silvicultural Prescription.
2. Prescribe burn the stands under conditions designed to minimise damage to the retained stems and promote regeneration. An FDI of 20–35 m/h and an SDI of less than 600 would be consistent with CALM guidelines for a tops-disposal burn. However, because of the complex pattern where rehabilitated areas and regrowth jarrah forest are intermixed, the whole area may initially need to be burnt at a lower FDI or under conditions of falling hazard in the late afternoon.

5.5.2 Implementation

The Water Corporation would appoint a project manager to oversee the funding, the contract arrangements and the implementation of this work to met the Corporation's outcomes and commitments.

As the Corporation does not have expertise in silviculture and burning, it is expected that the fieldwork will be contracted to CALM and FPC for implementation. The detailed scheduling, fieldwork and sampling that is required to prepare and implement the individual silvicultural or burning prescriptions would then be the responsibility of the contractors, who would also be responsible for compliance with the Forest Management Plan 2004–2013, the Codes of Practice and Timber Harvesting Manual relating to environmental protection standards and quality control. The Water Corporation would carry out regular and independent audit of these operations and would fund an annual third-party audit by the Conservation Commission. Where adaptive management requires change, these changes will be negotiated with the contractors.

5.5.3 Development of Key Performance Indicators (KPIs)

Key performance indicators (KPI) will be developed by the Water Corporation in consultation with stakeholders once the project is approved and will be part of the project's management plan. This will include providing data to the Forest Management Plan KPIs (see Appendix 4: Summary of Forest Management Plan KPIs). These should target water quality and quantity criteria, the safe handling of herbicides, the retained basal areas achieved, the efficacy of herbicide treatment, the level of damage in retained stems, the efficacy of the burn prescriptions, changes in stream invertebrates (e.g. biomass or functional group ratio), changes in indicator fauna species (e.g. cockatoo nesting or phascogale abundance), changes in understorey (using floristics), consultation and communication (e.g. research publications and frequency of newsletters and any reference group meeting). KPIs are an important part of adaptive management and provide a framework for monitoring project success and determining where improvements can be made. Associated with KPIs are strategies for managing variance from parameter target values.

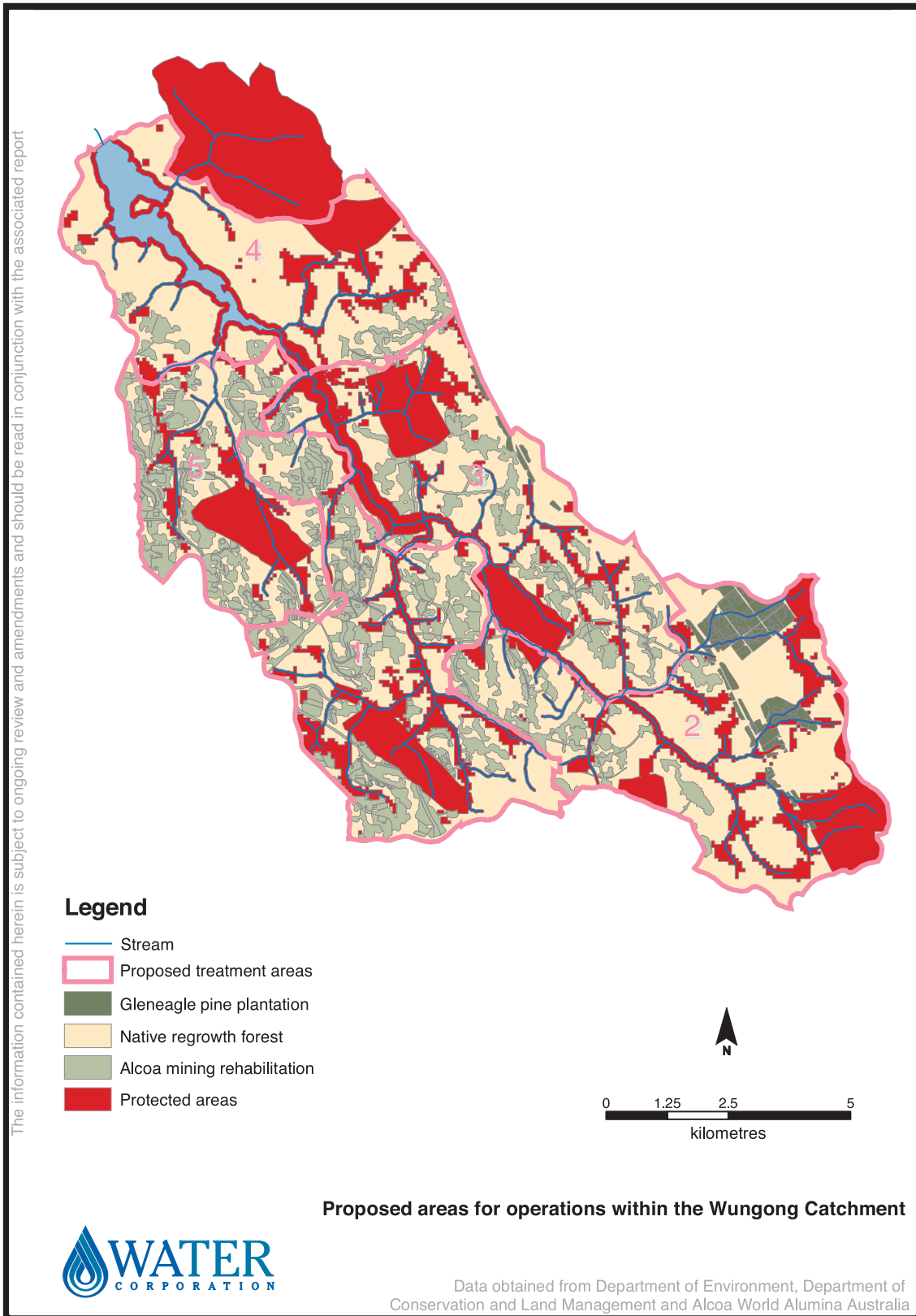


Figure 34 Sample sub-catchment location in Wungong Catchment

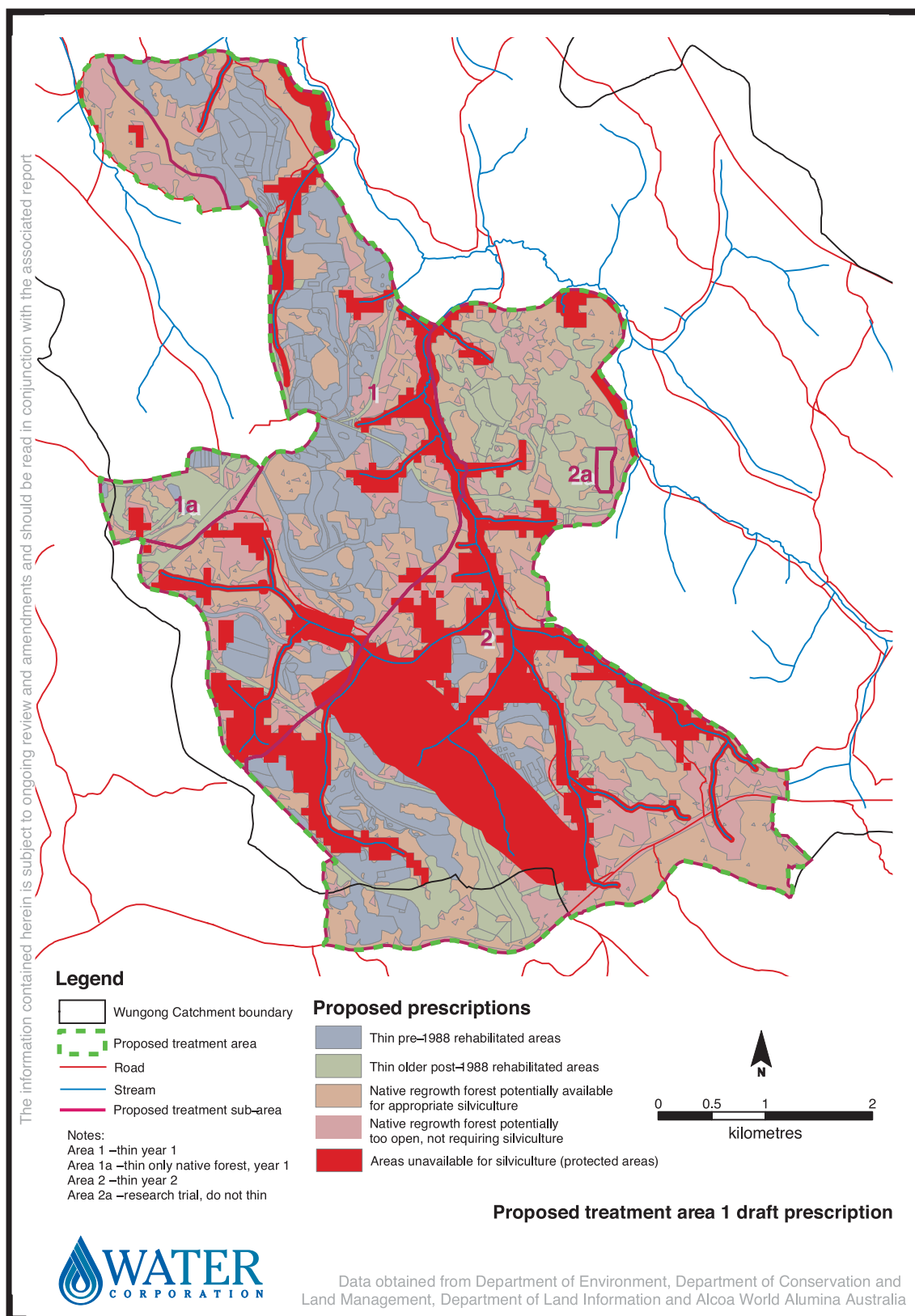


Figure 35 Sample sub-catchment prescriptions for treatment area 1



5.6 Adaptive management and governance

The precautionary principle can be used to help plan for events that seem most likely to occur, where there is uncertainty about impacts or solutions, e.g. a drier climate with less rain and less run-off, drought deaths, unhealthy vegetation, shifts in vegetation patterns, more summer cyclones, and more wildfire. If these are reasonable scenarios, then planning and research should examine what may be done to counter these changes, e.g. reduce competition within catchments, keep the forest vegetation healthy, encourage appropriate prescribed burning.

At the very least, alternative management scenarios should be researched, as is proposed by the Water Corporation in this document, so that data will be available on which to base serious future catchment management decisions. This project is therefore based on adequate monitoring and research, with the precautionary principle in mind and with effective public participation. The aim is to for the program to be collaborative and multidisciplinary, and the results communicated in a transparent way. The Water Corporation considered this approach to be adaptive management, and it would fit within the scope of Section 33.2 of the Forest Management Plan 2004–2013.

It is unreasonable to expect that knowledge on all aspects of the environment and of all effects of proposed treatments will be known with great accuracy at the beginning of a project such as this. Rather, an acceptable procedure should be to:

- ◆ identify the potential adverse effects on the environment as well as positive effects of the project;

- ◆ mitigate and minimise any potential adverse effects and maximise positive environmental benefits by the implementation of best practice prescriptions;
- ◆ monitor the effects of treatment on the specified environmental values and conduct appropriate longer term research;
- ◆ make these findings readily available to a wider public;
- ◆ review these results and incorporate the findings into revised best-practice prescriptions (adaptive management); and
- ◆ implement other positive environmental practices to achieve additional conservation benefits within the area to be treated.

Any proposed program needs to be acceptable environmentally. This project is expected to improve the sustainability of the Wungong Catchment and to be overall environmentally positive. However, there may be disbenefits to some components of biodiversity and the Water Corporation will fund projects with additional environmental benefits that mitigate the risk of any negative environmental effects of thinning (Section 5.6.4).

Possible areas of community concern of the proposed treatments are likely to relate to culling trees, terrestrial and aquatic biodiversity values (Section 6.1), potential for dieback spread and intensification (Section 6.1.1.4), issues related to water quality (Section 6.2), use of herbicides on a water-supply catchments (Section 6.2.2), nutrition and carbon (Section 6.3), utilisation of timber products (Section 6.3), aesthetic effects and potential impact on recreational values (Section 6.4).

The main positive effects of the proposed treatments relate to the maintenance of a hydrologic balance in the soil, streams and swamps in the light of a severe natural drying trend due to lower rainfall (Section 4.4), to the improvement of terrestrial biodiversity values in areas where exotic tree species will be converted back to native forest (Section 7.1), potential to increase streamflow and yield while maintaining water quality (Section 7.2), improved growth rates on areas that are thinned (Section 7.3), provision of employment (Section 7.3), and the lower requirement for energy as these catchments supply the metropolitan area by gravity (not pumping) (Section 7.4).

5.6.1 Indicative timeline

The project is a 12-year research trial which builds on past knowledge to provide more certain options for the future (Figure 36). The initial treatments will be phased in over four to six years with initially an increasing area treated each year. This will allow time for learning and adaptation. Depending on the success of the thinning there may be need for some coppice control over another four years. Rethinning of the retained stand may be required within the life of the project, although more likely this will be during years 15–20. The triggers for implementing each phase during the project will be based on managing to a basal area of 15–18 m²/ha. Depending on research, follow-up treatments may result in higher basal areas with wider spaced, larger trees.

As the area of catchment thinning increases, the streamflow will increase, but the full water benefit is gained in the second winter after any catchment thinning. The streamflow increase is expected to reach 8 GL/a over the first four to five years, then drop gradually until coppice control has another increasing effect on streamflow. The average additional streamflow from this 12-year project is estimated at 4–6 GL/a.

5.6.2 Implementing best-practice

Throughout this document the current best-practice procedures refers to those procedures that have been developed over several decades and implemented by various bodies, such as Alcoa, the Forests Department, CALM, FPC, DoE, and the Water Corporation. These best-practices have resulted from extensive research, monitoring and adaptive management carried out in the State forests over at least the past 40 years. This wealth of experience, contained in various Management Plans and Prescriptions, Codes, and Manuals must be the starting point for mitigating any potential negative effects from the implementation of the project.

In line with expectations from the community there is a continuing need to improve management of the forest through trialling improved procedures, monitoring, research, audit, publication of data, review and the implementation of change.

5.6.3 Monitoring and research

The Water Corporation will fund appropriate research, the collection of baseline data and monitoring by individuals and organisations not connected with the Water Corporation so as to have a degree of independent scrutiny of results. Appropriate bodies may include tertiary institutions, government departments (DoE and CALM) and statutory agencies (EPA, Conservation Commission) and specialist consultants. Existing monitoring systems, such as CALM's FORESTCHECK and DoE's hydrological measurement network, will be used where possible and augmented when required.

A technical reference group that includes CALM, DoE, FPC, Alcoa, as well as the Water Corporation has been formed to help develop the project and will continue to review the integrated annual works program. The role of this group will be expanded to provide expertise on proposed research, monitoring procedures and adaptive management. The membership of the group will be expanded to include the Conservation Commission of WA.



Key areas for research and monitoring could include the following:

- ◆ timing, quantity and quality of streamflow;
- ◆ groundwater trends;
- ◆ trends in aquatic biodiversity;
- ◆ trends in terrestrial biodiversity for selected key species of flora and fauna within rehabilitated pine plantations, treated stands of exotic eucalypts, re-treated dieback areas, thinned bauxite areas (native species) and thinned stands of jarrah regrowth;
- ◆ effects of thinning on the intensification of dieback disease;
- ◆ effects of variation in target basal areas on water and environment; and
- ◆ evaluation of community views especially on aesthetic and recreational values.

An important aspect is that these data be published (e.g. annual and project reports, theses, refereed publications) and be made available for regular review by any interested party. Comment and input from various sources will be sought by the Water Corporation.

As a result of experiences gained through implementation, audit, monitoring, research and wide scientific and public input, the field performance can be fully assessed and the best-practice procedures amended, as required. It is anticipated that the program of about 7800 ha will be implemented over 4–6 years, so there are opportunities to amend or improve prescriptions.

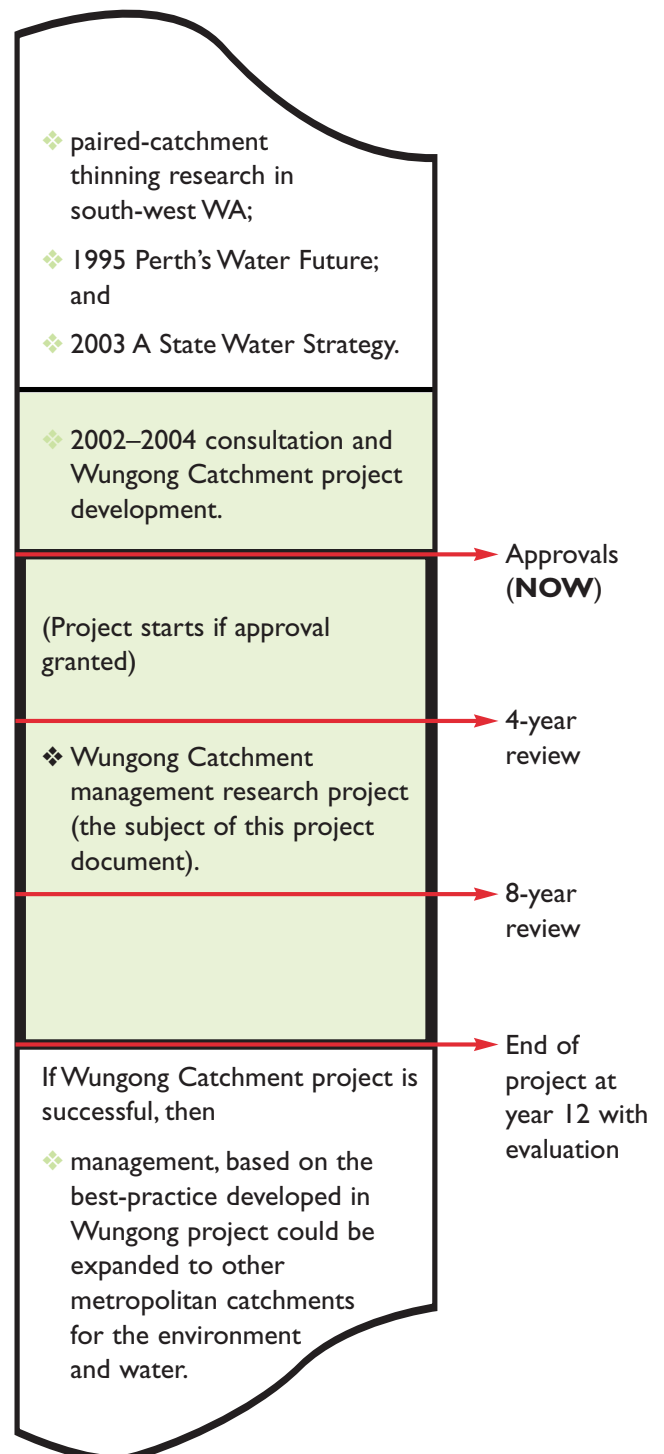


Figure 36 Events related to 12-year Wungong Catchment management project

Figure 11 shows the experimental sub-catchments, and the rainfall and stream gauging network within Wungong Catchment. Some of the rainfall measuring stations (pluviometers) and the Cobiac sub-catchment streamflow gauge are being reopened as part of this project. Waterfall Gully sub-catchment will continue as the control sub-catchment. Hydrological catchment modelling that has been initiated will continue through the project. There are existing environmental and water monitoring systems within Wungong Catchment. Alcoa has a significant number of permanent vegetation plots and done fauna trapping within the catchment which have several years worth of baseline data.

Research is required as part of adaptive management to reduce uncertainties about the ecological and water impact of the project. In the past, research has been fragmented and carried out at different locations with specific research questions. The Wungong Catchment management project as a 12-year research trial, will bring together different areas of science in the one location (Figure 37). A framework for knowledge integration will be created which includes:

- ◆ monitoring and analysis of data, and
- ◆ facilitating information exchange across different disciplines.

A research plan will be developed in consultation with local universities and others doing research (including Alcoa, DoE and CALM). Research proposals are being sought and a co-ordinated research approach will be adopted. Possible research topics include investigating the effect of catchment thinning on:

- ◆ local water cycle;
- ◆ soil moisture and shading;
- ◆ aquatic and terrestrial ecological system response;
- ◆ utilisation and development of hollows;
- ◆ fire and dieback risk;
- ◆ greenhouse gas emissions;

- ◆ feral bee control;
- ◆ community attitudes; and
- ◆ changes to understorey composition/density following various treatments.

A research-monitoring facilitator will be used to provide a link between various parties with differing aspirations, needs and timelines. The facilitator would bring the Corporation's needs, including feedback from the Project Manager, research topics raised by other stakeholders and specific field concerns, to the researchers. This would help to set appropriate research directions that are relevant to the Corporation.



Figure 37 Research needs to integrate across several disciplines

5.6.4 Making provision for additional environmental benefits

The Water Corporation is of the opinion that the project will benefit environmental values in this catchment, such as increase streamflow for aquatic ecosystem and decreasing the time for suitable habitat trees to form hollows. In addition to these benefits, the Corporation is willing to voluntarily provide funding for additional environmental enhancement programs to be implemented.



Examples of potentially suitable additional benefits should the Wungong project be approved, are:

- ◆ investigate control of feral honey-bees that compete for hollows;
- ◆ augment natural hollows by using nesting boxes;
- ◆ fund declared rare flora recovery plans;
- ◆ fund declared rare fauna recovery plans;
- ◆ consider funding introduction or relocation programs for fauna;
- ◆ intensify the baiting frequency within areas that are proposed for treatment;
- ◆ develop and undertake integrated research programs to establish relationships between proposed management regimes, the maintenance of terrestrial and aquatic biodiversity and site conditions in a range of forested catchments in different climatic zones;
- ◆ augment efforts on control of designated weed species;
- ◆ maintain and improve recreational facilities such as those at Langford Park and at Gleneagle, including provision of educational materials, brochures and guided forest tours; and
- ◆ consider establishing a 'discovery forest' within the catchment.

These have been developed in liaison with various stakeholders, the Conservation Commission and CALM. The Water Corporation has budgeted approximately \$80 000 per year or a total of \$960 000. These will require an assessment in terms of priority and this will be undertaken in consultation with stakeholders.

5.6.5 Continuing community involvement

The general community and peak groups, all have an important ongoing role with the Wungong Catchment management project. The Water Corporation had extensive consultation (Section 2) for developing the project in an open manner. This consultation will be built on during the project life, as consultation and communication are key parts of adaptive management. Methods of consultation the Water Corporation will use include:

- ◆ annual public reporting;
- ◆ reviews each four years;
- ◆ web-site;
- ◆ newsletters;
- ◆ technical reference group;
- ◆ possible community reference or Friends of the Wungong Catchment group;
- ◆ field trips; and
- ◆ presentations.

5.6.6 Auditing

The Water Corporation will regularly audit the implementation of the procedures in the field, in addition to the self-auditing required by the contractors (CALM, FPC, other). Also, the Water Corporation will fund an arm's length independent annual audit by the Conservation Commission. It is expected that this audit will be made public.

5.7 Environmental, legislative and policy framework and approvals processes

Environmental approval for a project such as this is the prerogative of the Minister for the Environment, on the basis of environmental advice provided by EPA, DoE, Conservation Commission as the vested authority, CALM as the forest managers, the Minister for State Development on the advice from the MMPLG (that has responsibilities with respect to areas that have been mined for bauxite) as well as industry and the public in a consultative process.

The Water Corporation's project for the Wungong Catchment has been designed to be consistent with approved Government Policy, with Legislative requirements and with the principles for environmental protection required by the EPA. Key documents include the State Water Strategy for Western Australia released in 2003 by the Premier; the principles of ecologically sustainable forest management found in the *Conservation and Land Management Act 1984*, the Forest Management Plan 2004–2013 produced by the Conservation Commission of WA (2003), the EPA's Position Statement No. 7 Principles of Environmental Protection (2002c) and the MMPLG's requirements for completion criteria for areas mined for bauxite by Alcoa.

5.7.1 State Government's Water Strategy

The State Water Strategy, on pages 39 and 40, foreshadows a potential additional run-off to existing dams from enhanced surface water catchment management activities of up to 40 GL over 10 years. The government's response is to support the development of improved catchment management activities and undertake a trial to investigate the impact of active catchment management strategies that enhance water quality and quantity outcomes.

Pages 55 and 56 of the strategy recognise the primacy of drinking water quality in the management of drinking water catchments to protect the long-term sustainability of the resource, and this will guide decisions on the management of the Wungong Catchment trial.

The project to enhance the streamflow of the Wungong Catchment by 4–6 GL/a by carrying out extensive management, rehabilitation and thinning trials with best practice to maintain water quality is seen as consistent with the implementation of this strategy.

5.7.2 Conservation Commission's Forest Management Plan 2004–2013

State forests are managed by CALM in accordance with the Forest Management Plan 2004–2013, the development of which was guided by the principles of ecologically sustainable forest management. *The Conservation and Land Management Act 1984* states that these principles are:

- (a) that the decision-making process should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations;
- (b) that if there are threats of serious or irreversible environmental damage, the lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- (c) that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations; and
- (d) that the conservation of biological diversity and ecological integrity should be the fundamental consideration in decision-making; and that improved valuation, pricing and incentive mechanisms should be promoted.



These principles form the basis for the Forest Management Plan 2004–2013 (Conservation Commission of WA, 2003). This plan is also in accord with the Montreal Process's criteria and indicators for forest management that include the maintenance of soil and water values, ecosystem health and diversity and global carbon cycles, as well as biodiversity, productive capacity, natural and cultural heritage and socio-economic benefits.

The Wungong Catchment management project as presented in this document is considered by the Water Corporation to be consistent both with the content of the Forest Management Plan 2004–2013, with the principles of ecologically sustainable forest management contained in the Legislation and with the Forest Management Plan 1994–2003.

Before work can commence, the areas to be thinned need to be included in CALM's logging plan. The area to be treated in the first three years have already been included. Before pine and other exotic plantations can be converted to native species, the approval of FPC and CALM will need to be obtained.

5.7.3 Environmental Protection Authority principles and policy

The EPA's Principles of Environmental Protection (2002c) outlined in its Position Statement No. 7, were prepared to "provide the public and key stakeholders with a summary of the key relevant principles of environmental protection that the Environmental Protection Authority considers to be important in guiding its decisions and advice to government on matters of environmental protection".

These 14 principles include: Environmental, Social and Economic Considerations; Precautionary Principle; Intergenerational Equity; Conservation of Biological Diversity and Ecological Integrity; Improved Valuation, Pricing and Incentive Mechanisms; Shared Responsibility; Product Stewardship; Eco-Efficiency; Waste Hierarchy; Integrated Environmental Management; Best Practice; Continuous Improvement; Accountability and Transparency; and Enforcement.

Other EPA documents of relevance include its Position Statement No. 3 (2002a), Terrestrial Biological Surveys as an element of Biodiversity Protection particularly page 5 that states the EPA's overarching principles for environmental impact assessment of biodiversity, and Position Statement No. 6 (2002b), Towards Sustainability especially pages 5–7 that discuss sustainability in natural resource management and page 13, managing for sustainability: triple bottom line reporting.

The EPA's (2003b) Draft Guidance Statement 55 'Implementing best practice in proposals submitted to the EIA process' proposes best-practice measures to prevent or minimise environmental impact and the risk of environmental impact occurring. It proposes the need for environmental management systems that include an environmental policy and corporate commitment as well as mechanisms and processes to ensure proper implementation and continuous review and improvement.

The Water Corporation considers that this Wungong Catchment management project has adequately addressed these Environmental Protection Authority principles as far as they relate to this specific project (see Appendix 1: Objectives and commitments).

5.7.4 Mining and Management Program Liaison Group (MMPLG)

The Minister for State Development on advice from the MMPLG, is responsible, on behalf of the State, for reviewing and approving Alcoa's 5 year rolling mine plans. The MMPLG (pursuant to the *Environmental Protection Act 1996*) has responsibility for overseeing, developing and approving the completion criteria that are considered as acceptable for rehabilitation of areas that have been mined for bauxite by Alcoa.

The MMPLG has undertaken an exhaustive review process over the past 4–5 years that included public input and field visits to sites. As a result of departmental and public inputs, completion criteria for Alcoa's rehabilitation have been approved by the MMPLG for both the pre- and post-1988 eras. The approved completion criteria are very comprehensive and are posted on the Department of Industry and Resources web-site.

Before rehabilitated bauxite mined areas can be thinned, the approvals of Alcoa, CALM and the MMPLG are required.

The main criterion that is of some concern to the Water Corporation, due to potential for reducing run-off, is the current requirement (post-1988 era) to maintain the over storey density at an average of 1300 stems per hectare at 9 months over 65% of the pit. At a later age there is a requirement for a minimum of 300 stems per hectare with the potential to produce trees with sawn timber potential.

For the pre-1988 era, the acceptable requirement is stated as "an average of 350 stems per hectare to be present at 12-years". It is also noted that "sites with less than 350 stems per hectare or with more than 1250 stems per hectare must be reviewed [by Alcoa] with Department of Conservation and Land Management to determine site-specific corrective action".

The mean stem density of 9–17-year old rehabilitation in Alcoa's Banksiadale catchment area was measured at 1200 stems/ha (which is at the upper end of the required 350–1250 stems/ha range).

While the pre-1988 mining rehabilitation is within the acceptable range (350–1250 stems/ha) they are at the higher end (1200 stems/ha). Current CALM guidelines recommend the release of at least 200 stems/ha where stems are less than 20 cm and stocking densities of 250, 180, 110 and 85 stems/ha at diameters of 22, 33, 45 and more than 50 cm respectively. At an average diameter growth of 5 mm/a these diameters could be reached by ages 44, 66, 90 and more than 100 years. However, with the growth rates currently observed in the rehabilitated pits, these diameters will be achieved at a much earlier age.

In practice there should be little conflict between the stocking densities required by good silvicultural practise, the stocking completion criteria determined by the MMPLG and the stocking densities appropriate to the needs of producing good quality and quantity water by the Water Corporation.

5.7.5 Department of Environment (DoE)

The DoE (joining Water and Rivers Commission and Department of Environmental Protection) is responsible for managing the State's water resources. Approval will be required from DoE before thinning can commence as the catchment thinning will be done in a drinking water catchment and involves culling vegetation and the use of herbicides approved for use in drinking water catchments. Section 6.2 explains how there is not expected to be any water quality impact from the project.



5.8 A team approach

The discussion above indicates that a partnership approach is essential to address the question of catchment management in the Darling Plateau catchments. Several departments with interests that do not necessarily align, as well as industry, the conservation movement and public perception will influence decision-making. What is optimum for a single department or commission may not necessarily be best for the State. Consideration should also be given to inter-generational equity so that what we do today benefits tomorrow's generations. Protection or enhancement of environmental values is seen as a key objective.

As integration in planning and management is required with flexibility, some compromises will be necessary. The economic benefits to timber production are delayed as compared with benefits to water yield, which are realised rapidly.

The economic 'winners' need to compensate those who will carry the major burden of costs or other appropriate mechanisms found. The completion criteria and Ministerial conditions set for Alcoa's rehabilitation and Diseased Forest Rehabilitation programs may also need to be reviewed.

Any perceived environmental costs need to be more than 'offset' by clear environmental benefits paid for by water revenues produced from the increased water yields.

A policy reference group is already being established with its initial task to look at how the mining rehabilitation areas could be thinned, as currently Alcoa is still responsible for them. This group includes senior members of the Water Corporation, Alcoa, MMPLG, FPC, CALM and DoE. This policy group has set up a technical reference group as mentioned in Section 5.6.3.

To ensure that statutory and policy requirements of the relevant agencies are met, a formal inter-agency structure and process will be established for discussion on implementation and management issues in the long-term.

6 Potential negative impacts and strategies to minimise them

The Water Corporation is confident this project will lead to positive environmental and water outcomes, but there is always a potential for negative impacts. This confidence is gained by successful past forest and catchment management, which provides guidance for strategies to minimise the risk of potential negative impacts.

To succeed, the trial needs to provide sustainable catchment management. Fortunately, given the current disturbed state of the Wungong Catchment (being either cleared and replanted, or regrowth forest), even if the project does not go as well as planned, it is not expected that the Wungong Catchment would become more degraded than its current state. This does not provide any reason for complacency, but does reduce the risk of a negative impact.

6.1 Biodiversity

The Panel Report on Ministerial Condition 11, Part 1, October 2001 (CALM, 2001) is the most comprehensive review of the environmental impacts of silvicultural treatments on jarrah forest. However, this report deals primarily with gap creation and shelterwood systems in mature southern jarrah stands at Kingston block. There are few data available on the effects of non-commercial thinning on biodiversity in the northern jarrah forest. The panel report makes recommendations for changes to silvicultural guidelines to ensure consistency with the principles of Ecologically Sustainable Forest Management. These recommendations are sound and where possible have been included into a best-practice prescription for non-commercial thinning in the Wungong Catchment.

As there has been limited research specifically on the ecological impacts of non-commercial thinning, past thinning trials can be assessed to gather data. A recent assessment was undertaken by Mattiske Consulting Pty Ltd (2004) for the Water Corporation on the previously established trial area at Inglehope near Dwellingup.

The data collected on this 40-year-old trial included species richness, plant densities and percentage foliage cover in various thinned areas. The trial area was relatively uniform and occurred largely within the T site-vegetation type, as defined by Havel (1975a). The Inglehope assessment reflected some consistency in the range of species present between the different thinning regimes. There were also local variations in some of the parameters measured, indicating that the variation in site conditions across the trial area may exceed the variation resulting from the thinning treatments. While there are some differences in the site-vegetation types between the Wungong and Inglehope area, there are also many similarities and therefore this assessment assists in developing an understanding of treatment regimes on other values at a patch size. It is intended to undertake similar trials in the site-vegetation types within the Wungong Catchment prior to and post the proposed thinning regimes.

A range of biodiversity values has been defined within the Wungong Catchment previously and the following is a brief overview of some of these values (Sections 6.1.1 and 6.1.2).

6.1.1 Botanical Values

The Wungong Catchment occurs on the western section of the Darling Botanical District of the South-western Botanical Province as recognised by Diels (1906) and later developed by Gardner (1942) and Beard (1979, 1980).

Previous workers have stressed the significance of the climate, landforms and soils in determining the distribution of plant communities in this area (Diels, 1906; Williams, 1932, 1942; Speck, 1958; Lange, 1960; Churchill, 1961, 1968; Smith, 1974; Seddon, 1972; Havel 1968, 1975a, 1975b; Heddle et al., 1980; Beard, 1981; Mattiske and Havel, 1998; and Havel, 2000).



In vegetation mapping it is necessary to define and map the plant communities into groups with common characteristics in structure and floristics. This grouping and classification has been achieved by:

- ◆ Havel on the Swan Coastal Plain (1968) and in the Northern Jarrah Forest (1975a, 1975b);
- ◆ Beard (1979) in the Pinjarra area (1:250 000);
- ◆ Heddle et al. (1980) in the System 6 area; Perth, Pinjarra and Collie areas (1:250 000); and
- ◆ Matiske and Havel (1998) in the vegetation mapping for the Regional Forest Agreement.

6.1.1.1 Vegetation complexes

The classification system of Heddle et al. (1980), and as recently updated by Matiske and Havel (1998) utilised the concept of vegetation complexes. The vegetation complexes reflected the relationships between the underlying landforms, soils and the plant communities. This latter system incorporated linkages with the previous work by Havel (1975a, 1975b) and extensive vegetation mapping on specific areas throughout the northern and central jarrah forest by Matiske.

The Wungong Catchment occurs on the western fringes of the Darling Plateau and includes seven vegetation complexes as defined by Heddle et al. (1980), and as recently updated by Matiske and Havel (1998) (see Figure 38):

- ◆ Dwellingup 1 – “Open forest of *Eucalyptus marginata* subsp. *marginata* – *Corymbia calophylla* on lateritic uplands in mainly humid and sub-humid zones.”
- ◆ Dwellingup 2 – “Open forest of *Eucalyptus marginata* subsp. *marginata* – *Corymbia calophylla* on lateritic uplands in subhumid and semiarid zones.”
- ◆ Murray 1 – “Open forest of *Eucalyptus marginata* subsp. *marginata* – *Corymbia calophylla* – *Eucalyptus patens* on valley slopes to woodland of

Eucalyptus rudis – *Melaleuca raphiophylla* on the valley floors in humid and sub-humid zones.”

- ◆ Yarragil 1 – “Open forest of *Eucalyptus marginata* subsp. *marginata* – *Corymbia calophylla* on slopes with mixtures of *Eucalyptus patens* and *Eucalyptus megacarpa* on the valley floors in humid and subhumid zones.”
- ◆ Yarragil 2 – “Open forest of *Eucalyptus marginata* subsp. *thalassica* – *Corymbia calophylla* on slopes, woodland of *Eucalyptus patens* – *Eucalyptus rudis* with *Hakea prostrata* and *Melaleuca viminea* on valley floors in subhumid and semiarid zones.” (this vegetation complex is often associated with the Swamp complex as follows).
- ◆ Swamp – “Mosaic of low open woodland of *Melaleuca preissiana* – *Banksia littoralis*, closed scrub of Myrtaceae spp., closed heath of Myrtaceae spp. and sedgelands of *Baumea* and *Meeboldina* spp. on seasonally wet or moist sand, peat and clay soils on valley floors in all climatic zones.”
- ◆ Cooke – “Mosaic of open forest of *Eucalyptus marginata* subsp. *marginata* – *Corymbia calophylla* (subhumid zone) and open forest of *Eucalyptus marginata* subsp. *thalassica* – *Corymbia calophylla* (semi-arid and arid zones) on deeper soils adjacent to outcrops, closed heath of Myrtaceae – Proteaceae species and lithic complex on granite rocks and associated soils in all climate zones, with some *Eucalyptus laeliae* (semi-arid), and *Allocasuarina huegeliana* and *Eucalyptus wandoo* (semi-arid to per-arid zones).”

The Forest Management Plan 2004–2013 aims to protect vegetation complexes that are less well reserved and important, by increasing the areas of these complexes within informal reserves (Appendix 5: Summary of Informal Reserves). None of the vegetation complexes in the Wungong Catchment falls into this category.

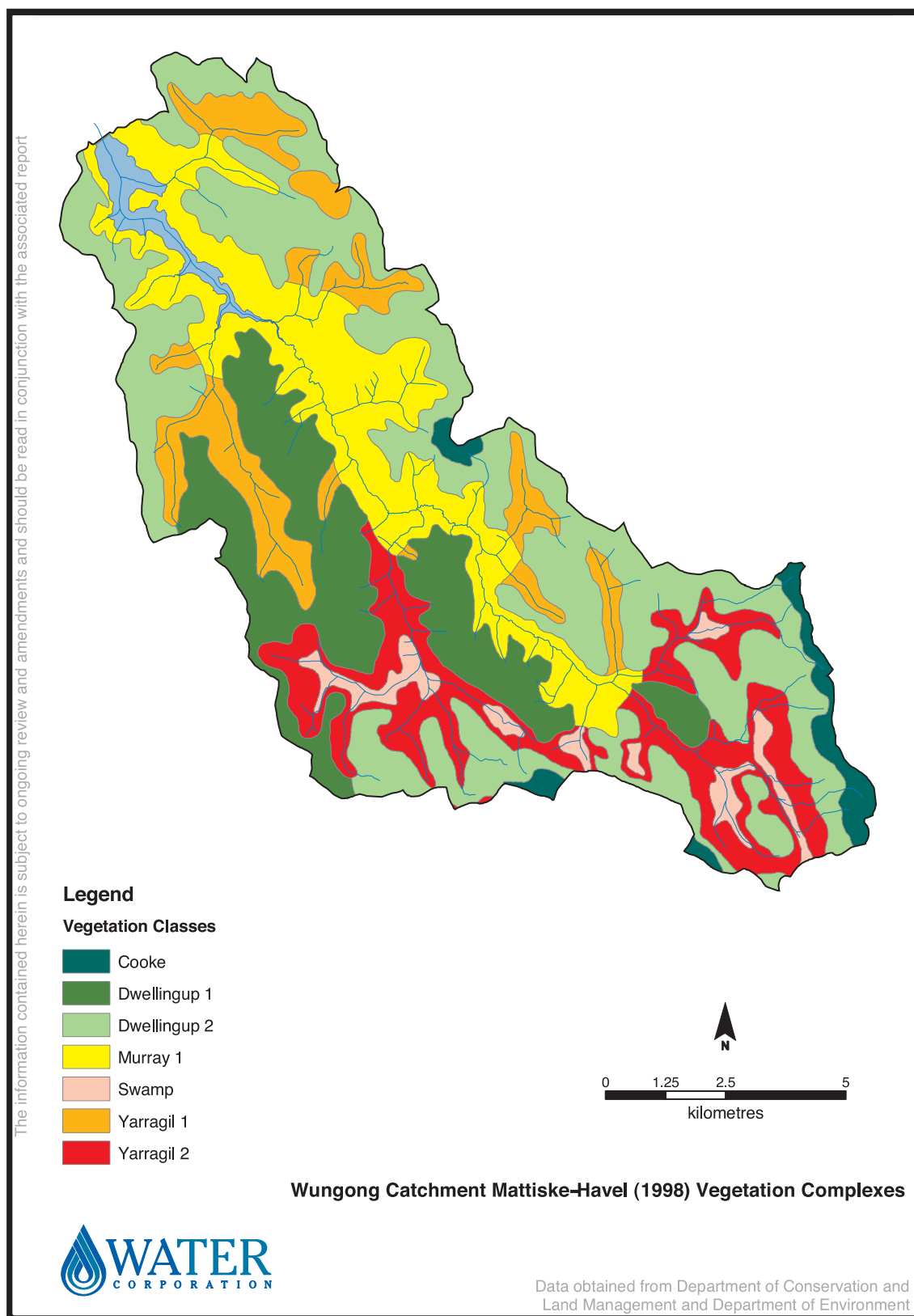


Figure 38 Wungong Catchment Mattiske-Havel (1998) vegetation complexes



6.1.1.2 Site-vegetation types

The site-vegetation types defined by Havel (1975a, 1975b) for the northern jarrah forest covered the variation of plant communities on this section of the Darling Plateau. Although the plant communities in this area form a continuum, it is possible to define the site-vegetation types by floristic information and structural information, supplemented by site descriptions (e.g. soils, topography, slope, aspect and soil moisture regimes).

Subsequent studies by E.M. Mattiske and Associates and Mattiske Consulting Pty Ltd in the northern jarrah forest in the past 20 years have recognised a series of new vegetation types not covered previously by Havel (1975a, 1975b). These include variations on the previously defined site vegetation types (e.g. PG, HS) as well as new site-vegetation types.

Detailed mapping of the central and eastern section of the Wungong Catchment has been undertaken by E.M. Mattiske and Associates (1993, 1994) prior to bauxite mining. Twenty-six site-vegetation types (including variants such as ST, TS) were defined and mapped. The site-vegetation types within Yarragil 2 and Swamp vegetation complexes, which are associated with broad valleys, as well as those site-vegetation types associated with the shallow soils over granite, were highlighted as significant from a biodiversity perspective. Any thinning operations proposed are unlikely to directly impact upon these sites, except for downstream changes in soil moisture levels. Research on these shifts in vegetation would assist in determining patterns of future changes in vegetation in response to climatic trends.

6.1.1.3 Declared rare and priority flora

A search of CALM (2002) and previous field results of E.M. Mattiske and Associates (1993, 1994) within and near the Wungong Catchment indicated that the following 28 threatened taxon (4 rare and 24 priority) could be in the Wungong Catchment as these species have been recorded within or near the catchment previously. These taxon include:

- ◆ *Acacia horridula* (P3)
- ◆ *Acacia oncinophylla* subsp. *oncinophylla* (P3)
 - *Acacia oncinophylla* subsp. *patulifolia* (P2)
 - *Acacia semitrullata* (P3)
 - *Andersonia saxatilis* (P1)
 - *Aotus cordifolia* (P3)
 - *Astroloma foliosum* (P4)
 - *Boronia tenuis* (P4)
 - *Bossiaea modesta* (P2)
 - *Calothamnus rupestris* (P4)
 - *Centrolepis caespitosa* (Rare)
 - *Chorizema ulotropis* (P4)
 - *Diuris micrantha* (Rare)
 - *Grevillea crowleyae* (P2)
 - *Grevillea drummondii* (P4)
 - *Grevillea manglesii* subsp. *dissectifolia* (P1)
 - *Grevillea manglesii* subsp. *ornithopoda* (P2)
- ◆ *Grevillea pimeleoides* (P4)
 - *Grevillea thelemanniana* (P4)
 - *Hibbertia montana* (P4)
 - *Lambertia multiflora* var. *darlingensis* (P3)
 - *Lasiopetalum bracteatum* (P4)
 - *Paracaleana dixonii* (Rare)
 - *Stylidium* sp. Boulder Rock (A Burbidge 2536) on (P2)
- ◆ *Synaphea acutiloba* (P4)
- ◆ *Synaphea odocoileops* (P1)
 - *Thelymitra stellata* (Rare)
 - *Thysanotus anceps* (P3)

The previous studies by E.M. Mattiske and Associates (1993, 1994) recorded some 293 taxa in the central and eastern sections of the Wungong Catchment. Of these 28 rare and priority species, three of the rare species (*Centrolepis caespitosa*, *Paracaleana dixonii* and *Thelymitra stellata*) are listed as endangered and one of the rare species is listed as vulnerable (*Diuris micrantha*) pursuant to s179 of the *Environmental Protection and Biodiversity Conservation Act 1999* (Environment Australia, 2003) (Figure 39).

The record of *Paracaleana dixonii* recorded near Brookton Highway (north of the catchment) has now been re-identified as *Paracaleana triens* (Brown, A., pers. comm.) and therefore the number of potential rare species has been reduced to two.

The silvicultural programs that are proposed, such as non-commercial thinning or the rehabilitation of exotic stands to native species, are not likely to affect these species adversely, as the majority of them have been recorded largely in shallow soils near rock outcrops (which will be protected, see Figure 18) or near the escarpment (which is outside the catchment). There is a need for further targeted searches for these rare and priority species. Fire frequency and intensity regimes may be of concern to the maintenance of some species, but the Water Corporation project does not diverge significantly from the burning program that CALM would routinely practise in this catchment.



Figure 39 Rare flora in Wungong Catchment (Photos by WA Herbarium)



6.1.1.4 Dieback disease

A large proportion of the western scarp in the high rainfall area is already affected by dieback (above 40%) and the remaining site-vegetation types generally show less susceptibility to the disease. Nevertheless, hygiene will be practised in all operations, as is now standard practice. Monitoring of hygiene logging trials shows that hygiene has successfully reduced the spread of the disease during logging operations. Stem injection and cut-stump operations are mostly carried out on foot with access provided by light vehicles on designated tracks. Any operation requiring off-road access by machinery in dieback free areas will be restricted to dry-soil conditions. Bauxite pits and areas planted with exotic species will be regarded as uninterpretable and appropriate clean-down will be required.

There is some concern that the improved water relations would lead to an increase in dieback expression within thinned stands, since direct inoculation with *Phytophthora cinnamomi* into jarrah roots and stems showed that the fungus grew more rapidly in the phloem tissues in the high rainfall zone during periods of reduced plant water stress (Tippett et al., 1987). In addition, the fungus was recovered more frequently from trees with reduced water stress (Bunny et al., 1995). With faster growth of the fungus, the plant is generally less able to occlude an invasion successfully. Thinning also increases soil and bark temperatures that may favour sporulation and dispersal of zoospores (Shearer et al., 1987; Kinal, 1993; Kinal et al., 1993) as well as lesion growth.

As a result of these concerns, experimental trials using direct inoculation of jarrah roots and stems were carried out in the Dwellingup area within three rainfall zones, high, intermediate and low. The stands were thinned to a 50% and 75% reduction of the pre-treatment basal area. Retained basal areas were low, for example in the high rainfall zone the basal areas were reduced from 28 to 11 and 7 m²/ha respectively.

Both are well below the basal area that is proposed for the Wungong Catchment area.

The rainfall zone where the trials were located, and the season, both had a major effect on the results (Bunny et al., 1995). Water stress in the trees was reduced by thinning, particularly in the low-rainfall zone. The greatest differences in fungal rates of growth were observed in the thinned areas in the low and intermediate rainfall zones and the least differences were observed in the high rainfall zone. The reason for this was not stated, but possibly in the high rainfall zone the phloem moisture content is often above a critical level for fungal growth whereas in the other rainfall zones, thinning allowed this critical threshold to be reached. However, as expected, the high rainfall zone showed the greatest lesion growth.

The results were also highly influenced by summer rain, with lesion length shortest in the dry summer of 1991 and longest in the wet summer of 1990. The seasonal effect due to summer rain appeared much more pronounced than the treatment effects of thinning. Over the 114 years of good record, the annual Jarrahdale rainfall (representative of catchment rainfall) has ranged from 680 to 2147 mm, making a three-fold variation (Figure 14). Such a difference greatly exceeds any soil moisture changes attributable to non-commercial thinning. Dieback spread and expression will continue to be largely dependent on rainfall (especially summer rainfall events) rather than thinning.

There are several ways that can be used to minimise the potential negative effects of dieback disease. For it to be a major concern in thinned stands, it needs to be present already or be introduced. Affected stands can be avoided and hygiene will be used to minimise the risk of introduction into unaffected stands. The retained basal area will also influence the soil moisture and resultant plant water stress.

It is proposed that the retained basal areas in native jarrah stands will be above 15 m²/ha, rather than the 7–11 m²/ha used in the experimental inoculation trials. Thinning will be preferred on those site-vegetation types where *Phytophthora cinnamomi* is less favoured (e.g. T, TS, ST and S).

Where required, a greater proportion of marri or other more tolerant trees will be retained during tree-marking operations.

The field evidence supports that this approach is possible. Twelve to 15 years after the thinning in the experimental water yield catchments (such as Yarragil, Higgins and Hansen) most of the individual trees that were retained after the thinning are alive and appear to be growing well, even in the Hansen Catchment where 30% were originally shown as affected by dieback.

Infection of jarrah by *Armillaria luteobubalina* may also cause crown dieback, small patch deaths and reduce the wood quality of any potential sawlog, by allowing wood rot fungi to establish. *Armillaria* infects the roots of living host trees by using stumps as a readily available food source to build up its inoculum potential. In the northern jarrah forest, infections by *Armillaria* are usually more prevalent in the lower rainfall area. The infection is readily observed by the appearance of large honey-coloured fruiting bodies during winter, or by the development of characteristic mycelial-fans under the bark of affected trees.

Should any sites affected by *Armillaria* be located in the Wungong Catchment, the options are: not to thin the area and to leave a suitable buffer, say 30 m around affected areas; to thin the area but to remove the stumps so as to reduce the inoculum potential; or to thin to a higher basal area and accept that the occasional tree death and some internal damage will occur.

6.1.2 Fauna

6.1.2.1 Vertebrate fauna

Ninox Wildlife Consulting (2003) prepared a potential list of fauna species for the Wungong Catchment area from unpublished data, a search of the literature, WA Museum's vertebrate fauna database and CALM's database. This includes 25 native mammals, 15 frogs, one aquatic tortoise, 47 reptiles and approximately 123 species of bird. Ten introduced animals made up of six mammals and four birds may also be present.

There is a small range of rare, threatened or vulnerable species that could occur within the Wungong Catchment, either as resident, nomadic or migratory species. These include three native mammals (the chuditch, quokka and numbat considered as resident), one reptile (carpet python, also a resident) and three birds (Carnaby's and Baudin's black cockatoo, resident/nomadic and peregrine falcon, nomadic) are listed as rare, threatened or endangered on both Commonwealth and/or State legislation. While listed on CALM's database for the Wungong Catchment area, the 1991 sighting of the rare (Commonwealth and State listed) western ringtail possum (*Pseudocheirus occidentalis*) was from the Gooralong Brook which drains into the Serpentine River. It is unlikely that this species would be present in the Wungong Catchment area.

Ten species are listed as vulnerable: the common wambenger, southern brown bandicoot, western brush wallaby, western false pipistrelle and water rats (mammals); Dell's skink (reptile) and the forest red-tailed black cockatoo, barking owl, masked owl and crested shrike-tit (birds).

In addition to the gazetted rare fauna, there are three birds protected under either the Japan-Australia or China-Australia Migratory Bird Agreements (JAMBA and/or CAMBA).



The silvicultural programs that are proposed such as non-commercial thinning or the rehabilitation of exotic stands to native species are not likely to affect these species adversely. The fauna species of more concern include the species that require hollows. The provision of nesting boxes; the retention of habitat trees, logs, and key mid-storey species; and the proposed increased frequency of fox-baiting after thinning or burning will offset any short-term effects of treatment. There is a need for further targeted searching and monitoring of some of the species within the catchment. This is proposed once approval has been obtained.

6.1.2.2 Stream fauna

Freshwater insects exhibit a high level of regional endemism (especially in the Scarp and forest edge zone) and a relatively low level of species richness (Bunn, 1986; Davis, J., *pers. comm.*). However, if intact buffers greater than 30 m either side of the stream are retained, as is proposed, the direct and possible negative effects of non-commercial thinning of jarrah forest on aquatic species should be minimal.

Jarrah forest stream invertebrates are naturally accustomed to some periods of drying, however the recent run of dry years has caused perennial streams to cease flowing. Thinning would improve environmental flows for riparian and stream biota. Any changes to the timing, permanence and fluctuations in flow resulting from thinning will be within the natural variability ranges previously experienced by these ecosystems. The likelihood is that extremes in flows resulting from thinning would be of a much lesser magnitude than the previous flows resulting from dieback infestations and mining activities. Monitoring of flows in gauged catchments will provide these data.

In addition these stream-zones (the majority of which are located within informal reserves) provide linking corridors for fauna as well as scope for penetration of some species into different climatic zones of the forested region.

6.1.2.3 Habitat trees and logs

Retention of an adequate number of habitat trees and logs is part of the standard silvicultural prescription required by the Forest Management Plan 2004–2013. Work by Whitford and Williams (2001) shows that the number of hollows increase with tree age, tree size and the amount of dead wood in the canopy. Also marri has greater probability of containing a number of useful hollows. Work by Abbott and Whitford (2002) identified that 42 species use hollows in the forest. No species were considered to be in immediate or high risk, 17 species that are totally reliant on hollows for breeding, eight of which have very small home ranges. These eight species (six bird and two mammals) were very dependent on hollows and are deemed to be excellent for monitoring purposes. These species were the brush-tailed possum, phascogale, rufous tree-creeper, sacred kingfisher, red-tailed black cockatoo, ring-necked and red-capped parrots. These authors conclude that existing best-practice prescriptions provide adequate safeguards.

Tree hollows are very important for fauna habitat. Trees that are good as habitat trees are also the larger, older trees with less leaf area and hence are useful for water quantity as well, with more rainfall ending up in the stream (Figure 40).

As well as increasing streamflow, catchment thinning is also good for producing habitat trees. Thinning will allow trees to grow faster and produce larger trees earlier. A good habitat tree needs to be 50 cm in diameter before it has large enough limbs to drop off and produce good sized hollows. Without thinning it would usually take 110 years for a tree to reach 50 cm, but with thinning this may only take 70 years. That is, catchment thinning will produce habitat trees earlier. Hence, the Water Corporation want to move our dense regrowth forests back towards a mature state as this will improve environmental and water values.



Figure 40 Potential habitat tree in Wungong Catchment (Photo by Colin Terry)

6.1.3 Minimisation of adverse environmental impacts

The general management techniques that will be used by the Water Corporation to minimise any adverse effects of non-commercial thinning on biodiversity are as follows:

- ◆ no thinning in stream buffers, heathland, fauna habitat zones, and open areas;
- ◆ minimal fragmentation of habitat;
- ◆ control of exotic and weedy species;
- ◆ no removal of larger debris from forest floor;
- ◆ retention of the larger trees with greater potential for hollows;
- ◆ retention of key components of the understorey (e.g. large banksia);

- ◆ increased fox-baiting;
- ◆ evaluation of the feasibility of feral bee control;
- ◆ provision of nesting boxes; and
- ◆ investigate measures to control vermin such as feral pigs.

6.2 Water quality

Drinking water quality and ecological water quality are important to maintain. Currently Wungong Catchment produces high quality drinking water and the project would ensure through use of best practice this would continue. A draft Wungong Brook Dam Catchment Area Drinking Water Source Protection Plan is in preparation. The project is consistent with this document.

6.2.1 Salinity and turbidity

The salinity of the water in this catchment is low (approximately 30 mS/m at 25°C, equivalent to 165 mg/L total dissolved solids) despite the very severe and extensive changes in land-use that have occurred over the past 100 years of activity since settlement. Most of the catchment lies in the higher rainfall zone (above 1100 mm), where salt storage values are usually low (Schofield et al., 1989). The proposed disturbance by non-commercial thinning to a basal area of 15–18 m²/ha is therefore most unlikely to cause a problem with salinity (Bari and Ruprecht, 2003).

The deep soils and mild landforms characteristic of the northern jarrah forest (Churchward and Dimmock, 1989) give considerable stability to landscape. However if logging and, more importantly, roading and stream crossings are not properly designed, there is some potential to increase sedimentation and turbidity (Stoneman et al., 1989). No major new road construction is planned, except for re-opening part of a recently rehabilitated old haul road.



Unlogged buffer areas will be left on all streams in accordance with EPA requirements and the provisions of the Forest Management Plan. Other appropriate controls will be imposed on non-commercial thinning operations as specified in the silvicultural prescriptions and on any commercial harvesting as specified in the Contractors' Timber Harvesting Manual (FPC, 2003). Previous operations have not caused significant concerns, even when only a pipehead dam was operating in this catchment.

Data from local trials and from elsewhere show that buffer widths of 30 m on each side of a stream are generally sufficient for logging operations, even on steep slopes (Borg et al., 1988). In addition, bauxite mining has been carried out for over 40 years on water supply catchments, in proximity to existing dams without major problems of turbidity. However, if any serious problems should occur, which is unlikely, they will be reported and the Water Corporation can take this dam off-line until the problem is resolved.

The wide areas of exposed soil on steep slopes, now found adjacent to the Wungong Reservoir require monitoring and management in order to reduce turbidity within the reservoir from wave action and severe rainfall events. Studies carried out by Havel (*pers. comm.*) showed that vegetation on the periphery of the Wungong Reservoir tends to be more frequently inundated than is the case with larger reservoirs such as Canning and South Dandalup.

6.2.2 Use of herbicides on water supply catchments

There are two main techniques for non-commercial thinning jarrah forest with herbicides, to fall the tree and immediately spray or paint the stump with herbicide (cut-stump) or to inject the herbicide directly into the tree (stem-injection). The former costs between three and four times more than stem-injection (e.g. \$1000/ha rather than \$300/ha).

The herbicide used is 'Roundup' (active ingredient glyphosate), a herbicide approved for use within water supply catchments by the Public Health Department's Pesticides Advisory Committee (Public Sector Circular 88 – Use of herbicides on water catchment areas). This circular permits the use of glyphosate for cut-stump, stem injection and as a direct foliar spray to control coppice and advance growth (when there is no lower risk alternative). Roundup is found in the majority of Perth's garden sheds and is widely sold for home foliar control of weeds. The Water Corporation believes that the use of glyphosate for catchment thinning has a lower water quality risk than the alternative thinning methods (see Appendix 6: Herbicide water quality risk assessment).

There is some low potential for 'flashback' to occur due to root contact (where herbicide moves through roots to effect a tree near the one treated), but this is usually in less than 5% . This can be reduced further by dilutions of the order of 1:4 and by not injecting or spraying stumps that are within one metre of a retained stem.

CALM has thinned some thousands of hectares on water supply catchments using these techniques, in accordance with the prescriptions and safety requirements contained in CALM's Herbicides and Chemical User's Manuals.

Roundup is a non-selective, contact herbicide registered for use in Western Australia (see Department of Agriculture web-site), it is widely used and is non-residual and readily detoxified if inadvertent contact with the soil occurs. It is regarded as of low toxicity to humans and animals. Using best-practice will reduce the risk of any spills, but if they occur they will be reported immediately to DoE, Public Health and the Water Corporation and the Wungong Dam can be taken off-line until the spill is dealt with as part of the dam's normal operation.

When there is treatment close to the reservoir (e.g. within RPZ), currently planning is for it to be timed to coincide with when the dam is off as part of its normal operation.

For all these reasons, no public health concerns resulting from the use of Roundup are anticipated (Appendix 6: Herbicide water quality risk assessment).

6.3 Nutrition, carbon and bio-fuels

The jarrah forest ecosystem has the capacity to cope well with low nutrient availability (Hingston et al., 1989). The jarrah forest ecosystem has well-developed mechanisms for nutrient recycling and nitrogen fixation. In view of the low nutrient levels, management should be such that nutrient cycling is encouraged, that losses are minimised or replaced and that species that fix nitrogen are encouraged. The prescriptions need to keep this in mind and be adapted to local variations in nutrient levels.

If the thinning is done by stem-injection, all plant material remains on the site and minimal losses of nutrients are anticipated. Also, with the trees left standing, less material is burnt, which further reduces any nutrient losses. Cut-stump also retains these materials on-site, but a larger proportion of the ground fuel is consumed. Hingston et al. (1989) concluded that nutrient loss due to logging and burning was low in the jarrah forest because of effective biochemical nutrient recycling.

In native forests the project does not anticipate the widespread removal and sale of firewood or bio-fuel from the thinned areas, though a small volume of higher-value products such as jarrah sawlogs and poles may be available for sale through the FPC, under the approved Forest Management Plan and CALM's logging plans.

In older mining rehabilitation plantations, the project does anticipate the sale of small volumes of chip, sawlog and firewood.

This thinning would be part of a staged conversion of the exotics to natives (by thinning, under sowing with natives, and a progressive removal of exotic species).

In pine plantations, which have mostly been harvested during 2004 by FPC, the project is where mutually acceptable arrangements can be made between FPC, CALM and the Water Corporation, for these areas to be rehabilitated to natural forest.

Data from various studies show that there are large quantities of 'waste' or bio-fuel that may be produced by various activities in the forest. These may range from 300 t/ha after bauxite mining to as low as 6 t/ha from thinning of jarrah in rehabilitated bauxite pits (Alcoa, *pers. comm.*). The Water Corporation is aware that two states (NSW and Victoria) have banned the use of native forest by-products for use as bio-fuel, and understands that this activity is not favoured in Western Australia by either the government or the Conservation Council.

In this Water Corporation project, the preference is for non-commercial thinning by stem-injection. The responsibility for developing markets and managing the sale of commercial products lies with other agencies (e.g. FPC and CALM) or industry. These matters will need to be addressed separately by CALM and FPC.

A calculation has been made to determine whether the project will produce or sequester carbon dioxide. The calculation estimated the additional growth that will result from thinning and then subtract potential losses caused by the gradual decay of these dead trees or of products from them. Separate estimates are made for plantations established on bauxite pits and for regrowth jarrah forest. Data sources include published reports from CALM, Forests Department, Alcoa and the Australian Greenhouse Office (AGO) as well as personal communications with CALM and FPC staff.



Measurements of growth and increment are normally for tree boles, this being the parameter that are more easily measured and for which growth data and models exist. Clearly there is also growth of roots, branches and leaves, and loss/decay of these components all contributing to the carbon balance on the site. For the purposes of this calculation, the total volume of all components is estimated as twice the bole volume (the default value suggested by AGO). All other factors, e.g. prescribed burning regimes, respiration by soil flora, etc., are considered to be neutral, on the assumption that the areas will be periodically burnt, whether or not thinning proceeds, so as to avoid a long build-up of leaf, twig and log material and that normal soil processes will continue. Also, as the Wungong Dam uses gravity to supply the IWSS, there was no energy used in pumping and associated greenhouse gas emissions.

The result of the calculation was that approximately 700 t/a of CO₂-equivalent would be sequestered by the project, but given the uncertainty of the growth rates and decay rates used, it was concluded the project would be approximately greenhouse neutral.

6.4 Aesthetic and recreational values

6.4.1 Management of aesthetic values

Consideration of visual resource management criteria is required for all logging operations and appropriate prescriptions are covered in the Codes of Practice and Manuals. Large, widely-spaced trees with sparser understorey can be quite an attractive feature, as evidenced by mature stands, the 100-year forest, the Big Brook–Treen Brook stands near Pemberton, the Inglehope stands between Dwellingup and Boddington, and the Mundlimup area near Jarrahdale (Figure 41).

However, an immediate reduction from 37 to 7 m²/ha as occurred at Hansen's experimental catchment was considered by many to look quite drastic in the field.

A better alternative would be to thin dense stands initially by no more than 50%.

The thinning technique itself is also important. The most cost-effective technique is stem-injection with Roundup at a cost of about \$300/ha. This retains the trees standing until they fall or are utilised as firewood. The standing trees are very obvious at the 'brown-top' stage before leaf fall, but once leaf fall has occurred, they blend well into the surrounding forest. These standing trees with dead tops and dry bark are a fire hazard during prescribed burning or wildfire suppression. To minimise this hazard, thinning by felling and stump treatment should be used for 30–50 m (depending on the height of trees) around prescribed burn boundaries, at a higher cost of about \$1000/ha. Adequate crop-tree protection measures will be taken prior to a fuel reduction burn to reduce the thinning debris and an appropriate SDI selected, probably less than 600, in order to minimise scorch.

Stands where the trees to be thinned are felled rather than notched may be more pleasing aesthetically, but the cost of treatment is increased about three-fold. If implemented according to prescription, each method is equally effective. Costs may be reduced with training, competence and economies of scale. However the efficient implementation of the procedures is paramount, since retreatment of areas because of a below-average result is extremely costly. Although more expensive, the cut-stump technique will be preferred around areas of higher public visitation such as major travel routes, walk-trails and picnic areas. Alternatively a buffer will be left and these areas will not be thinned. Further consultation with the public is proposed.

6.4.2 Recreation management

Recreation can cause water quality issues in a drinking water catchment if not well managed. The Water Corporation prefers recreation activities to be outside the catchment, in particular in the excellent picnic facilities just downstream of the Wungong Dam (Figure 43 and Figure 43). It is important to remove unmanaged human activity from the reservoir protection zone (extending 2 km from the high water level of the reservoir), and away from streamzones within the catchment. The consultative water source protection planning process run by DoE will develop a plan for water quality risk management within the catchment. A draft plan capturing the issues has been developed, with the next stage being public consultation.

There is a strong culture of day-walking from Jarrahdale and this could be augmented with signage and track work, in particular where trails are near areas to be treated as part of the Wungong Catchment management project. Guided tours within the catchment are also planned with best management for water quality protection, which could involve bus tours to different treatment areas within the catchment and allow the public into areas the Water Corporation would otherwise discourage them from going due to the water quality risk.



Figure 41 Mundlimup research plot near Jarrahdale, thinned 1928 (Photo by Colin Terry)

Figure 42 Wungong Dam site map showing public facilities including picnic area



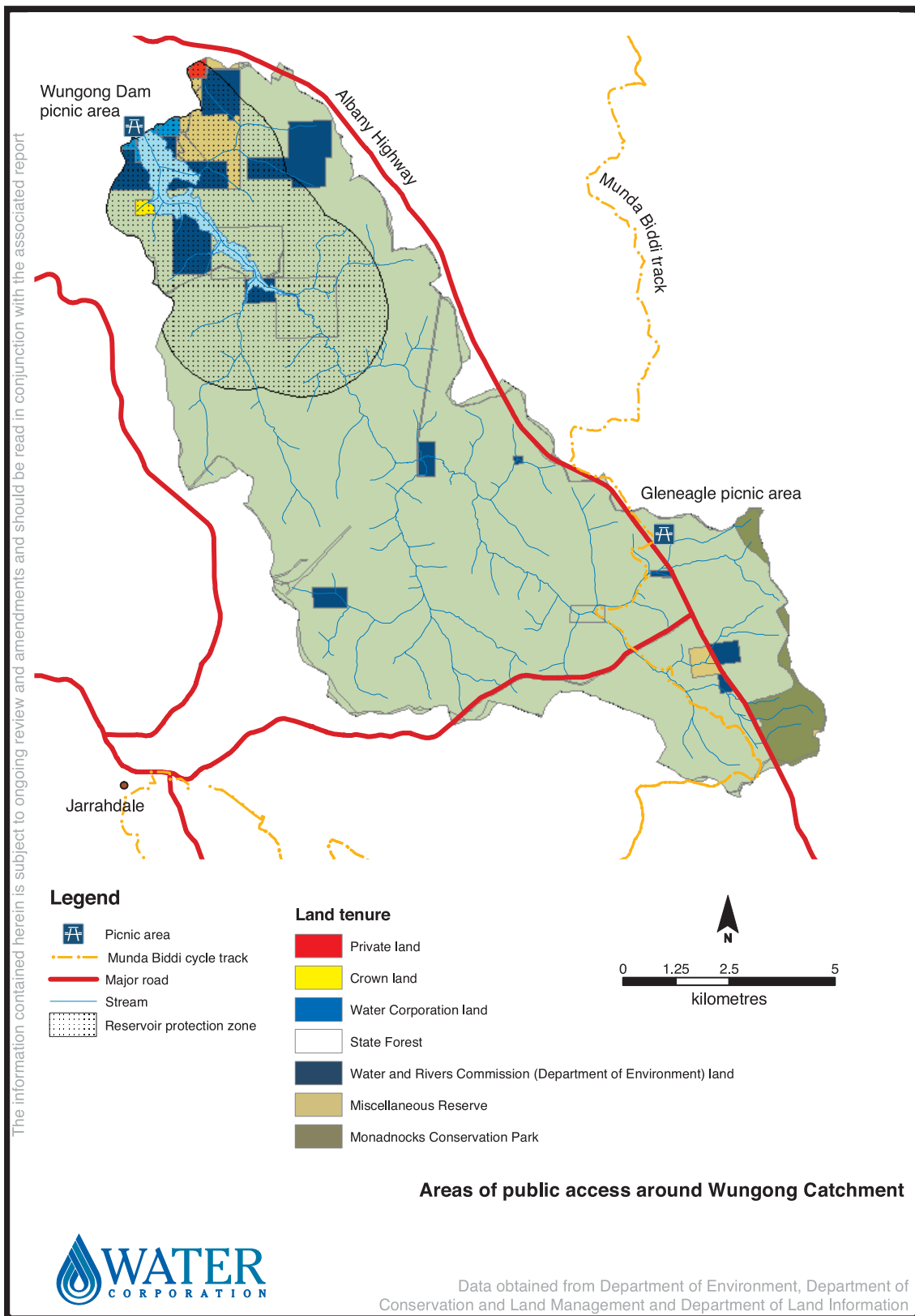


Figure 43 Areas of public access within and around the Wungong Catchment

7 Potential positive effects

7.1 Effects on biodiversity

The key site-vegetation types of high value to biodiversity are the swamps and riparian vegetation for terrestrial and aquatic fauna and rocky areas, associated heath-lands and non-forest areas for flora. It is proposed that all these areas, as well as their appropriate buffers, will not be treated (Figure 18).

Any increases in water yield will counter the current drying trends observed in both rainfall and run-off from these catchments and the observed recent drying of some forest streams formerly regarded as perennial. These trends should benefit flora and fauna in these water-gaining sites and in streams. The Wungong Catchment will provide a comparison with State forest and National Parks that will not be thinned. Also, there is less chance of drought deaths and of insect or fungal attack on healthier trees.

In addition, the thinning will target the smaller diameter regrowth stems and not the mature components of the jarrah forest that are usually of higher value as fauna refuges. The value of larger stems of banksia, balga, *Persoonia* and sheoak is also recognised and these species will be retained either as individuals or in patches within the areas to be thinned.

Thinning will change the forest structure to a more open stand with fewer, larger trees, which will provide opportunities for some understorey species to develop and will approach some of the characteristics of older-growth forests. Also, bigger trees with larger limbs will encourage the development of large hollows at an earlier age, as these limbs are damaged and lost (Abbott and Whitford 2002) (Section 6.1.2.3).

The proposed conversion back to native species of pine plantations and pine plots, of dieback areas and of bauxite areas that were initially planted to exotic species, will also have a positive effect on biodiversity over a significant area of the catchment (at least 11% of the catchment).

Also some sites will be seeded with natives when there is no non-commercial thinning carried out to enhance their environmental values, this includes the areas of mining rehabilitation and dieback affected sites planted to exotic species. The proposed additional control of foxes, bees and feral pigs will also improve biodiversity values.

7.2 Improving water quantity and quality

The proposal to non-commercially thin jarrah forest to increase water yield was first practised on a large scale in Western Australia in the areas adjacent to Mundaring Weir in the early 1900s. Unfortunately this area falls into the intermediate-low rainfall zones and some salinity problems were experienced. The regrowth was then allowed to re-establish on the catchment. Some farm areas were resumed and then planted with pines.

The idea received new impetus in the 1980s with the Forest Department proposing that a Water Production Priority Area be established in the higher rainfall zone (over 1100 mm) in its Land-use Management Plan. A number of catchment trials were then established near to Dwellingup by the Water Authority and Forests Department (Higgins, Hansen, Jones, Yarragil 4L) and thinned in the mid-to late-1980s. Data are now available for 13–17 years after treatment, and have been reported on in several published papers (Ruprecht et al., 1991; Ruprecht and Stoneman, 1993) and Water and Rivers Commission and Water Authority reports (1997, 1987 respectively). The data was summarised by the Steering Committee on Land-use and Water Supply in its 1987 report (Water Authority of Western Australia, 1987) and more recently by the Department of Environment (Bari and Ruprecht, 2003).

Basal areas prior to thinning in the experimental catchments ranged between 35 and 43 m²/ha and canopy cover between 46 and 54%. These basal areas were then reduced to 7, 15, 17 and 12 m²/ha for Hansen, Higgins, Jones and Yarragil 4L respectively.



The average pre-treatment water yields were quite low – 70, 30, 12 and 10 mm out of rainfall in excess of 1000 mm. After treatment substantial increases in annual yield were observed, from 90 to 300 mm, reducing over time to between 55 and 110 mm as the tree crowns expanded and regrowth, particularly coppice from stumps, began to compete for water. The data show a lag time of between 2 and 8 years between treatment and maximum water yield and then a decrease in yields over the next 8 to 10 years. These results emphasise the importance of controlling regrowth in the intervening period between thinnings if water yields are to be maintained.

The 1987 Steering Committee report suggested a target of about 10 m²/ha basal area to produce an annual increase of about 150 mm in yield. They calculated that the area in the high rainfall zone north of Dwellingup of 460 km² could produce an extra 64 GL of water of which about 37 GL would be utilisable by the present infrastructure. The thinning program would be staged over a number of years requiring the treatment of between 4000 and 6000 ha each year. Their estimate of costs of production was low, less than \$0.10/kL and a largescale operational trial in the Scott sub-catchment of the South Dandalup Dam was recommended, but was never implemented.

More recently, the Water Corporation requested Matiske Consulting Pty Ltd to prepare a review titled “Catchment management options for increasing water yield from forested catchments while protecting or enhancing the environment 2002”. A more conservative estimate of basal areas maintained around 15 m²/ha and a 100 mm increase in yield was chosen for this review, which meant that an area of 1000 ha of thinned forest would produce an additional 1 GL, at an estimated cost of \$0.20/kL.

Increase in streamflow in the Wungong Catchment expected from this project is shown in Figure 44.

The increased streamflow has been plotted as a dashed line relative to the past hydrology to show the streamflow is not being moved into a new regime. In the 1975–1996 regime the increase moves the flows back towards the wetter pre-1975 period, while for the 1997–2003 regime the increase almost maintains the 1975–1996 flows.

Prescribed burning also has the capacity to increase water yields, especially if carried out in autumn just prior to the winter rains, if located within or adjacent to ‘source’ areas and if the program covers large areas of the catchments each year. However, the effects of a prescribed burn on yield will be short lived as the tree and shrub crowns recover, and in the order of one or two years. This recovery is rapid, especially with areas burnt in spring, as the main flush of growth occurs in the following summer (McArthur, 1964). Water quality can also be impacted upon by prescribed burning and wildfires, with too hot a burn resulting in damaged vegetation and causing ash and turbidity problems. This is demonstrated by the wildfires around Canberra in January 2003, which caused large problems for the environment and public water supply.

Previous studies at a 10-year time scale (Batini et al., 1980) showed a weak correlation between the area prescribed burnt and increases in water yield in the Wungong Catchment. Regular and extensive prescribed burning does increase water yields but not to anywhere near the degree that thinning or that mining and dieback does. In general, a catchment in which fire is well managed for biodiversity, wild fire risk reduction and asset protection, can also be well managed for water quality and quantity.

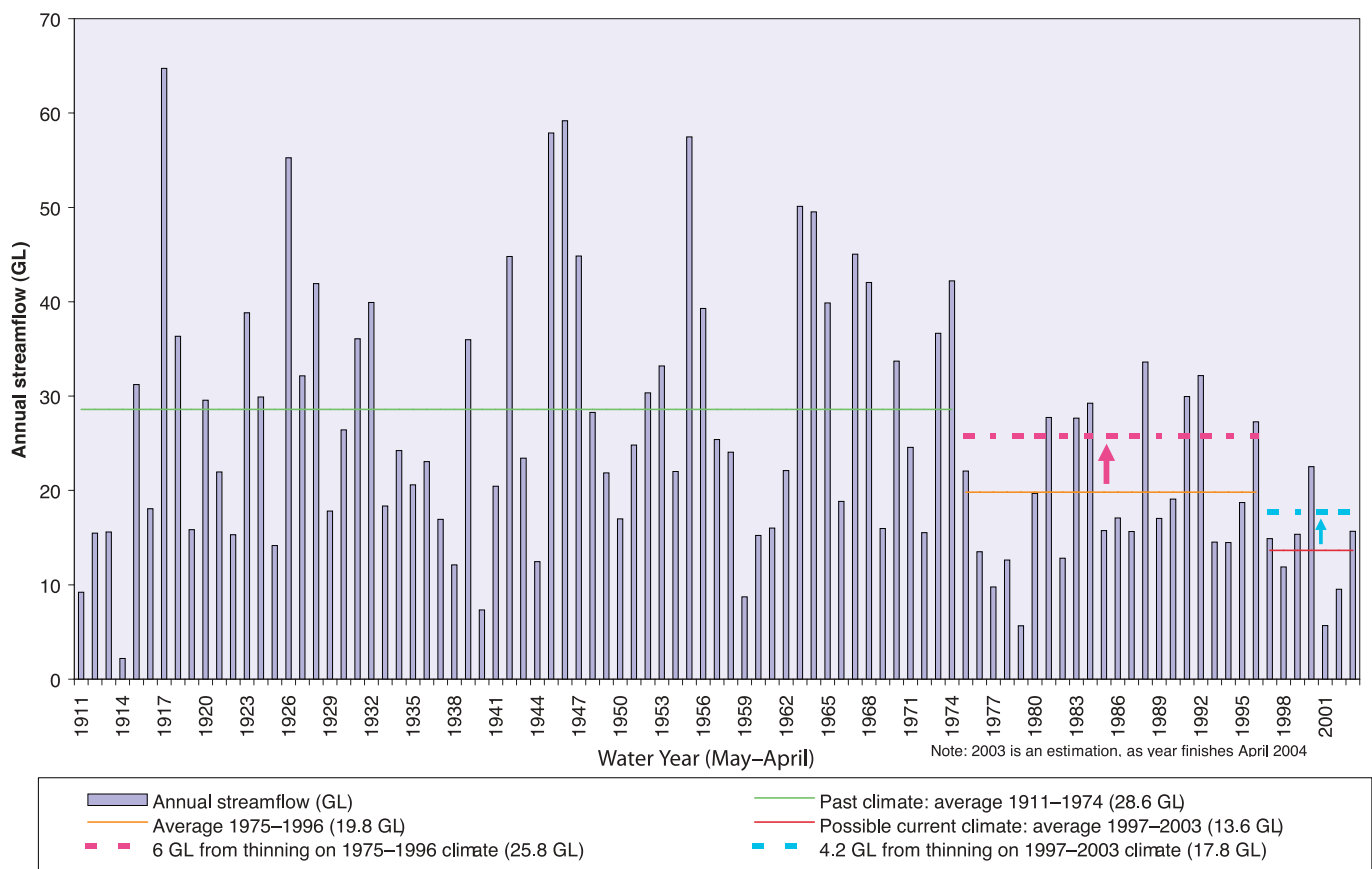


Figure 44 Streamflow increase expected in Wungong Catchment for different climate scenarios

7.3 Effects on timber growth, yield and employment

Thinning has long been recognised by foresters as a way to concentrate diameter increment on select trees while not sacrificing volume production. Thinning reduces water stress and allows a longer growing season. Data show that for jarrah, basal area and volume increment are maximised between 12 and 22 m²/ha basal area, a reduction in stand density of about 30 to 70% over the current 35–40 m²/ha basal areas of regrowth stands (Stoneman et al., 1996).

Diameter increment increases linearly with decrease in basal area, optimum diameter increment being recorded at basal area of about 7 m²/ha. At such a low basal area there is a significant loss in both basal area and volume increment.

CALM's silvicultural guideline suggests the following schedule for timber production objectives for stand density, which includes habitat trees. The schedule is shown in Table 5 for the high rainfall zone (with crop tree density in brackets).



Table 5 Schedule for target basal area as a function of tree diameter

Tree diameter	Target basal area
Less than 20 cm	15 m ² /ha $\approx$ greater than 475 stems/ha (200 crop tree stems/ha)
20–25 cm	15 m ² /ha $\approx$ 375 stems/ha (12 m ² /ha for crop trees)
25–40 cm	16 m ² /ha $\approx$ 145 stems/ha (13 m ² /ha for crop trees)
40–50 cm	18 m ² /ha $\approx$ 115 stems/ha (15 m ² /ha for crop trees)
greater than 50 cm	20 m ² /ha $\approx$ less than 100 stems/ha (17 m ² /ha for crop trees)

A good balance between timber and water production would be to maintain stands at between 15 and 18 m²/ha (depending on size) by periodic thinning and coppice, regrowth and some banksia and sheoak control. This would require follow up treatments at regular intervals using mechanical (cutting) or chemical (application of Roundup) techniques. At these densities, diameter growth rate of about half a centimetre per annum are achievable (Stoneman et al., 1996), which would result in a tree of 50 cm diameter or more being produced from existing stands in about 70 years.

Given that much of the area in the Wungong Catchment is dieback affected or unprotectable, and of moderate to high impact, most areas would be marked to retain 15 m²/ha for dieback reasons, as required by CALM's silvicultural prescriptions.

The size of the trees to be removed would continually increase over time. The materials produced would correspondingly progress from numerous small logs at a young age, which currently have no ready markets, to fewer logs of good size and form suitable for high-grade uses such as furniture making.

Within 3–4 decades if utilisation of these logs were approved by government, commercial thinning of older the stands will be self-funding.

The independent panel reporting on the calculation of sustained yield for the Forest Management Plan (Ferguson et al., 2003) recognised the importance of thinning to increase timber yield and acknowledged the potential of thinning for water as a means of economically achieving both objectives.

There would also be a modest increase in employment in forestry work, in monitoring, research and activities associated with education and recreation. It is expected that the residents of Jarrahdale would share in some of these benefits.

7.4 Reducing energy requirements

The Water Corporation is committed to the greenhouse challenge of reducing energy usage, and so greenhouse gas emissions. The water collected from the Wungong Dam is gravity-fed to the metropolitan area reducing energy required for pumping from alternative sources (e.g. Harvey Dam or Gngangara Mound).

If an additional 4–6 GL/a can be produced by thinning, the equivalent savings in energy would range between 3000 to 13 000 tonnes of CO₂-equivalent per year (compared to an equivalent 4–6 GL produced from new south-west groundwater or seawater desalination sources).

Thinning produces more dead wood which would release carbon more quickly to the atmosphere than living trees, but it also increases the growth rate of the retained trees that act as a carbon sink (Table 2 and Section 6.3).

7.5 Increasing knowledge

The application of best-practice catchment management to the Wungong Catchment, in particular with the monitoring and research being conducted, will improve the knowledge to help future forest and catchment management. Uncertainty about future climate states and associated biological response means all extra knowledge will be useful in ensuring sustainable management of our water and environment systems.

With the open process being conducted by the Water Corporation and its focus on consultation to bring the community and regulators with it on this journey, there will be secondary knowledge benefits. These include improving public understanding of the issues, providing tours, signing walking-trails, publishing brochures, and potentially developing a demonstration forest.



Whether this Water Corporation project is accepted or not, commercial logging operations, fire and forest management will continue in the jarrah forest. If the catchments were all forested with old-growth forest, which they are not, then there would probably be an ideal balance for water and the environment, and the Water Corporation would not need to propose catchment management that includes a focus on water quantity. The majority of the catchments contain native regrowth forest, and so there is an opportunity created for the environment and water, as these two values would benefit if the regrowth forest were moved towards a mature state.

This project will, if approved, apply adaptive management at a catchment scale for the environment and water, which will tie the value of extra water gained through catchment thinning to an improved funding for forest management. The Water Corporation will implement the proposed 12-year project in accordance with its commitments and in consultation with stakeholders (Appendix 1: Objectives and commitments).

The Water Corporation has designed this project to be consistent with the Conservation Commission's Forest Management Plan 2004–2013 and it is based on current best-practice forest management. This includes consistency with

- ◆ permissible operations on various land tenure and their purpose;
- ◆ sustained yield and other extractive levels;
- ◆ silvicultural practices and operational guidelines;
- ◆ environmental protocols;
- ◆ mining rehabilitation completion criteria;
- ◆ rate and scale of disturbance activities;

- ◆ capacity to accommodate the project within operational schedules (mining, timber harvesting, burning, other) at an acceptable rate; and
- ◆ adequacy of monitoring and research program.

The project's main objective is for water production in the short-term and sustainable forest management, which is good for water production, in the long-term. The focus of the project is not for sawlog production, although thinning will be beneficial as it increases the growth of the retained trees.

The drying climate in south-west WA adds a sense of urgency to active management, as the environment, in particular the aquatic ecosystem, is heavily influenced by a forest that is over stocked, and is not well placed to cope with the additional stress of further declines in rainfall.

From a water perspective, the project is to restore catchment streamflow by an average of 4–6 GL/a (25%). This water has a present value of approximately \$60 million and will benefit the environment and our water resources. For sustainable management of water services, the Water Corporation has adopted a security through diversity approach to maintaining a supply-demand balance. This includes a range of demand management, treated wastewater recycling and new source development projects. The Wungong project is part of this suite of projects, and potentially the first step in a larger catchment management project if the Wungong project is approved and is shown to be successful. The Wungong project will produce a low-cost and high quality water supply. As the Wungong Catchment is in the high rainfall zone, it has a very low store of salt in its soil profile and very low risk for salinity problems.

New water sources have social benefits as water is vital for life and a reliable high quality water supply is important to the community.

8 Conclusions

Even with reducing per capita consumption and recycling of treated wastewater, there is still a need for new water sources as the population grows and the climate becomes drier. The project has other social benefits in

- ◆ providing a limited amount of employment for forestry and research workers;
- ◆ engaging the general community transparently to increase their knowledge and make them part of the decision making process; and
- ◆ improving the aesthetics of the forest in the longer term (Figure 45).

As the project is a low cost water source, with a unit cost of \$0.23/kL, this will defer the need for some future more expensive water sources, with their associated environmental risks, and could defer some rate increases for water consumers.

The Water Corporation expects there will be an environmental improvement due to the catchment thinning and staged conversion of exotic tree species to native species in this project. Thinning will also restore streamflows to help aquatic fauna and decrease the time for a tree to be large enough for use by hollow-dependent fauna as habitat. As this project is approximately greenhouse neutral, there is a saving by developing catchment thinning water sources compared to more energy intensive sources.

Good governance is vital for ensuring the project gets implemented according-to-plan and the benefits are realised. There is a large stakeholder group for catchments and their values, and a whole of government approach is required to address the complex integration of policies and understanding. The knowledge gained from this adaptive management project through monitoring, researching, independent auditing and feedback from the community and peak stakeholder organisations, will help future forest and catchment management.

The risk of potential negative impacts from the project are minimal due to the use of best-practice. There are also risks from not doing this project, as well as benefits from the project proceeding. On balance, the Water Corporation considers it worthwhile to conduct this project to improve our knowledge and so reduce uncertainty, in particular as it is expected this century will be hotter and drier than the last.

On environmental, social, economic and governance criteria, this project provides for management of our catchments in an adaptive management framework. It provides hope to the community that into the future they will have both a reliable high quality drinking water and a good environment. The Water Corporation believes in sustainable catchment management.



Figure 45 Thinned forest near Dwellingup – sustainable catchment management? (Photo by Colin Terry)



9 Contributors to project preparation

9.1 List of Participants

The first discussion paper was written by consultants (Mr Frank Batini, Dr Joseph Havel and Dr Libby Mattiske) for the Water Corporation. The final project based on the discussion paper and incorporating stakeholder feedback was prepared by Water Corporation staff Dr Colin Terry, Ms Amanda Reed, and Mr Frank Batini (consultant), with input from Mr Keith Barrett, Dr Bob Humphries, Mr Graeme Hughes, Mr Chris Botica, Mr Steven MacKenzie, Mr Mike Thorman and Mr Peter Engler (Water Corporation).

9.2 Acknowledgements

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Ms Sally Robinson (Consultant), Mr Roger Underwood (Consultant), Mr Jack Bradshaw (Consultant); Mr Keith Low, Mr Alan Seymour and Mr Gavin Butcher (Forest Products Commission); Mr John Gardner, Mr Ken McIntosh, Dr Carl Grant (Alcoa); Mr John Ruprecht, Mr Mohammed Bari (Department of Environment); Mr Hans Jacob (Environmental Protection Authority Service Unit); Mr Mike James and Mr Louis Bursztyn (Mining and Management Program Liaison Group); Mr Chris Tallentire and Dr Beth Schultz (Conservation Council of WA); and Mr James Duggie (WWF Australia).

In more general terms we wish to acknowledge the constructive input from our stakeholders (such as those on the September 2002 Wungong Catchment tour shown in Figure 3, Figure 46, and Table 8 of Appendix 3: 27 September 2002 field trip), all of whom have added value to this project through their questions, observations and feedback.



Figure 46 Field trip participants at Jarrahdale old growth site, September 2002 (Photo by Colin Terry)

10 Glossary

Basal area	The sum of the cross-sectional areas of trees greater than 10 cm in diameter for a particular plot area (above or below bark, usually above bark) – measured at 1.3 m above ground (usually in m ² /ha).
Biodiversity	The variability among living biological entities and the ecosystems and ecological complexes of which those entities are a part and includes: (a) diversity within native species and between native species; (b) diversity of ecosystems; and (c) diversity of other biodiversity components.
Catchment	A landform that catches or collects water, especially rainwater, for a stream or reservoir.
Climate	A description of meteorological parameters such as rainfall and temperature for a region, that characterises variations in these parameters, including annual averages based on a particular range of years.
Climate change	Variations in a climate regime on a timescale from several years to many decades, caused by both natural and human-induced change (i.e. both natural variability and enhanced greenhouse effect).
Coppice	Sprouting of vegetation after it has been stressed as part of regeneration.
Coupe	Area of forest planned for harvesting as a single unit, which may contain several silvicultural objectives.
Culling	The deliberate felling, treating with herbicide or pushing down of unwanted overstorey or understorey species, usually to reduce competition to retained trees or for establishing regeneration.
Cut-over	Logged or harvested.
Cut-stump	A thinning technique where a tree is fallen (cut down) and the stump is sprayed or painted with herbicide such as glyphosate (Roundup).
Dam	Structure constructed to control flow and impound a reservoir of water.
Dieback	A process where vegetation declines or dies, usually caused by a combination of environmental stress (e.g. lack of rain) and disease, and in the south-west of Western Australia a disease of plants caused by infection by the soil-borne organisms of the genus <i>Phytophthora</i> .
Direct run-off	Rainwater entering a stream that has only flowed over land (not interflow).
Ecosystem	A community or an assemblage of communities of organisms, interacting with one another and the environment in which they live.
Enhanced greenhouse effect	Process where human-derived gases trap energy from the Sun to heat the Earth (an enhanced version of a natural process).
Evaporation	Process of changing water from a liquid to a vapour, which results in water being lost from a catchment to the atmosphere.
Evapo-transpiration	Combination of evaporation and vegetation transpiration.



Exotic	Non-local provenance (e.g. Australian eastern state tree species planted near Perth).
Fauna	Animals including mammals, birds, reptiles, amphibians and invertebrates.
Feral Flora	An introduced or domestic animal now living in the wild plants including flowering and non-flowering plants, ferns, mosses, lichens, algae and fungi.
Forestry	Cultivating, maintaining, and developing forests.
Gap cutting	Silvicultural objective that creates a discrete opening in the overstorey canopy created to reduce competition to allow seedlings to become established and or develop.
Glyphosate	Herbicide that is approved for use in drinking water catchments (sold as Roundup).
Groundwater	Water that moves through geological structures under ground.
Herbicide	Chemical that kills plants.
Hollows	Holes in older trees used by animals as habitat.
Interflow	Rainwater entering a stream that has first infiltrated through the ground.
Landing	Area where harvested logs are stockpiled for loading.
Lignotuber	Below ground survival mechanism that can resprout after existing ones are destroyed.
Logging	To cut down and trim trees, and haul timber from a piece of land.
Nesting box	Artificial nest used to provide habitat for birds.
Overstorey	Upper stratum of the forest (usually larger trees such as jarrah and marri).
Prescribed burning	Burning that is planned to achieve specific management objectives (compared to wildfires, which are unplanned).
Reservoir	Body of water impounded, usually behind a dam.
Roundup	Herbicide that is approved for use in drinking water catchments, which has glyphosate as the active ingredient.
Run-off	Amount of rainwater flowing out of a catchment from interflow and direct run-off (often expressed as a percentage of rainfall).
Senescing	Crown dieback often due to age.
Shelterwood	Silvicultural objective that involves the removal of some mature trees and action to establish regeneration under the remaining mature trees; and when the regeneration is sufficiently established most of the remaining mature trees are removed to allow the regeneration to develop.
Silviculture	The theory and practice of managing forest establishment, composition and growth to achieve specified management objectives.
Snig track	Route through forest for dragging fallen trees to a landing or for loading.

Soil Dryness Index	A predictor of the deficiency of soil moisture in a hypothetical soil profile having 200 mm capacity, from 0 at field capacity to 2000 when dry.
Source area	An area of catchment near streamzone that becomes wetter during winter and produces direct run-off.
Stakeholder	Someone or some organisation that has an interest in an issue or project.
Stand	A group of trees or patch of forest that can be distinguished from other groups on the basis of size, age, species composition, condition or other attribute.
Stem-injection	A thinning technique where a tree's trunk is notched once or more with a small axe, and herbicide (such as glyphosate) is injected into each cut.
Sub-catchment	A catchment within a larger catchment.
Surface water	Water that moves overland and in water courses.
Stream order	Classification system for width and importance of streams, varying from 1 for minor streams in upper catchment, to 5 for major streams or rivers.
Streamzone	A vegetation system close to streams.
Thinning	Silvicultural objective that culls selected trees, that in this project is used to improve the growth of retained trees and allow the catchment to produce extra run-off.
Transpiration	A process where water that has been absorbed by plants is transferred to the atmosphere via the leaves of the plant.
Treatment	Silvicultural change to forest through physical intervention (e.g. thinning, planting, gap creation).
Understorey	Lower stratum of the forest (usually shrubs and ground cover, but also includes smaller trees such as banksia, <i>Persoonia</i> and sheoak).
Unit cost	Present value of the cost to develop a water source, divided by the "present value" of the volume of water provided by the source.
Water quality	Living and non-living things in water that determine how safe it is for drinking and the environment (described by salinity, turbidity, pathogen and chemical levels).
Water year	For surface water in south-west WA a May to April hydrological year is used, with the quoted year being the beginning of the water year which includes the winter.
Yield	Used for both water and timber resources to describe how much volume of product is obtained per year from a dam or forest area.



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Appendix I: Objectives and commitments

Table 6 EPA factors and objectives for project assessment

	Factor	Environmental Objective	Relevance to project	Section in which factor discussed
Integration	Biodiversity	To avoid adverse impacts on biological diversity, comprising the different plants and animals and the ecosystems they form, at the levels of generic diversity, species diversity and ecosystem diversity.	Yes	6.1 and 7.1
	Sustainability	To ensure, as far as is practicable, that the proposal meets or is consistent with the sustainability principles in the National Strategy for Ecologically Sustainable Development (Commonwealth of Australia 1992).	Yes	3.2, 3.3, 5.6 and 5.8
Biophysical	Flora	To maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	Yes	6.1.1
	Fauna	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	Yes	6.1.2
	Wetlands (wetlands, rivers)	To maintain the integrity, ecological functions and environmental values of wetlands.	Yes (only rivers)	5.2.1
	Water (surface or ground)	To maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance, are protected.	Yes	7.2
	Land (terrestrial)	To maintain the integrity, ecological functions and environmental values of the soil and landform.	Yes	5.4 and 6.2.1
	Land (marine)	To maintain the integrity, ecological functions and environmental values of the seabed and coast.	No	Located far from seabed and coast
	Conservation Areas	To protect the environmental values of areas identified as having significant environmental attributes.	Yes	5.2.1



Pollution management	Air quality	To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land-uses by meeting statutory requirement and acceptable standards.	Yes	5.3.2
	Water quality (surface, marine or ground)	To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land-uses by meeting statutory requirements and acceptable standards.	Yes	4.5 and 6.2
	Soil quality	To ensure that rehabilitation achieves an acceptable standard for soil quality compatible with the intended land-use, and consistent with appropriate criteria.	No	No rehabilitation involving earth works
	Noise	To protect the amenity of nearby residents from noise impacts resulting from activities associated with the proposal by ensuring the noise levels meet statutory requirements and acceptable standards.	No	No nearby residents as operations within catchment
	Radiation	To ensure that radiological impacts to the public and the environment are kept as low as reasonably achievable and comply with acceptable standards.	No	No radioactive materials being used
	Light	To avoid or manage potential impacts from light overspill and comply with acceptable standards.	No	No lighting used
	Greenhouse gases	To minimise emissions to levels as low as practicable on an on-going basis and consider offsets to further reduce cumulative emissions.	Yes	7.4
Social surrounds	Heritage	To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant legislation.	Yes	4.2
	Risk	To ensure that risk from the proposal is as low as reasonably achievable and complies with acceptable standards and EPA criteria.	Yes	5.1 and 5.6
	Visual amenity	To ensure that aesthetic values are considered and measures are adopted to reduce visual impacts on the landscape as low as reasonably practicable.	Yes	6.4.1

Social surrounds	Recreation	To ensure that existing and planned recreational uses are not compromised.	Yes	4.6 and 6.4.2
Other	Decommissioning	To ensure, as far as practicable, that rehabilitation achieves a stable and functioning landform which is consistent with the surrounding landscape and other environmental values.	No	No significant Water Corporation infrastructure being built

Table 7 Water Corporation project commitments

#	Topic	Actions	Objectives	Timing	Advice from	Report section
1	Biodiversity	Implement management techniques such as: • no non-commercial thinning in stream buffers or heathland; • minimal fragmentation of habitat; • control of exotic and weedy species; • no removal of larger debris from forest floor; • retention of the larger trees with greater potential for hollows; • retention of key components of the understorey; • increased fox baiting; • evaluation of the feasibility of feral bee control; and • provision of nesting boxes.	Minimise any adverse effects of non-commercial thinning on biodiversity.	Throughout project.	Conservation Commission CALM Serpentine-Jarrahdale Shire Alcoa Conservation Council Academia	6.1.3



#	Topic	Actions	Objectives	Timing	Advice from	Report section
2	Sustainability	Ensure project's management plan is consistent with the Forest Management Plan objectives and intent. Contribute data to relevant Forest Management Plan key performance indicators.	Fulfil the obligations of the Forest Management Plan.	Throughout project.	Conservation Commission CALM	1.6 5.5.3
3	Sustainability	Develop Key Performance Indicators to target: • water quality and quantity criteria; • safe handling of herbicides; • achievement of retained basal areas; • efficacy of herbicide treatment; • level of damage in retained stems; • efficacy of burn prescriptions; • changes in stream invertebrates; • changes in indicator fauna species; • changes in understorey; and • consultation and communication.	Measure project performance.	Prior to the start of forestry activities.	DoE Conservation Commission CALM FPC Serpentine-Jarrahdale Shire Alcoa Conservation Council Academia Public	1.6 5.5.3
4	Sustainability	Develop detailed silvicultural prescription maps for on-ground activities within entire catchment.	Describe silvicultural treatments at a level of detail useful for on-ground activities.	Prior to the start of forestry activities.	Conservation Commission CALM FPC Alcoa	5.1 5.4.3 5.5

#	Topic	Actions	Objectives	Timing	Advice from	Report section
5	Sustainability	Prepare an adaptive management plan using phased implementation of treatments over 4 to 6 years and best practices that: • mitigate and minimise any potential adverse effects and maximise positive environmental benefit of all proposed treatments by the implementation of best-practice prescriptions; • understand the likely adverse and positive effects on the environment; • monitor the effects of treatments on the specified environmental values and conduct appropriate longer-term research; • communicate findings to a wider public and specific stakeholder groups; and • review and audit results and incorporate the findings and stakeholder feedback into revised best-practice prescriptions (adaptive management).	• implement other positive environmental practices to achieve additional conservation benefits within the catchment. • uses the precautionary principle; • considers the catchment holistically; • allows adjustment of prescriptions (including ceasing if adverse impacts cannot be ameliorated) based on stakeholder feedback, monitoring and research; and • integrates and describes partnerships, roles, and planning for monitoring, research and communication.	Prior to the start of activities.	Conservation Commission CALM FPC DoE Serpentine-Jarrahdale Shire Alcoa Academia Public	3.3 4.3 4.4.3 5.1 5.2.3 5.6 5.6.1 5.6.2 5.6.3 5.6.4



#	Topic	Actions	Objectives	Timing	Advice from	Report section
6	Sustainability	Provide funding to individuals and organisations not connected with the Water Corporation for • appropriate research; • collection of baseline data; • monitoring; and • auditing.	To have independent scrutiny of results.	Throughout the project.	Conservation Commission CALM Academia	4.3 5.6 5.6.3
7	Sustainability	Develop and fund ongoing program of environmental improvement projects within the catchment.	Complement longer-term environmental enhancements from silvicultural treatments with shorter-term environmental enhancements.	Throughout the project.	Conservation Commission CALM Serpentine-Jarrahdale Shire Alcoa Academia	5.6 5.6.4
8	Sustainability	Manage and communicate monitoring and analysis of data, and discipline specific research outcomes, with stakeholders and all researchers.	Facilitate knowledge integration and transfer between researchers.	Throughout the project.	CALM DoE Alcoa Academia	5.6.3

#	Topic	Actions	Objectives	Timing	Advice from	Report section
9	Sustainability	Involve the community through methods including: • annual public reporting; • four yearly reviews; • web-site; • newsletters; • continuation of policy reference group; • continuation of technical reference group; • field trips; and • presentations.	Consult openly with community and partner with stakeholders.	Throughout the project.	Conservation Commission CALM FPC DoE Serpentine-Jarrahdale Shire Alcoa Academia Public	5.6.5
10	Sustainability	Regular auditing to be undertaken by: • water Corporation on the implementation of procedures in the field; • contractors (CALM, FPC and others) on the work undertaken for their contract with the Water Corporation; and • an independent third party (the Conservation Commission), to be funded by the Water Corporation and results to be made public.	To have independent scrutiny of project impacts and outcomes.	Throughout the project.	Conservation Commission CALM FPC	5.6.6



#	Topic	Actions	Objectives	Timing	Advice from	Report section
11	Flora	Monitor the flora in Yarragil 2 and Swamp vegetation complexes.	Ensure that thinning operations do not adversely impact site-vegetation types of high biodiversity value.	Prior to activities starting and throughout the project.	Conservation Commission CALM Serpentine-Jarrahdale Shire Alcoa Academia	6.1.1.2
12	Flora	Undertake further targeted field searches for rare and priority species.	Ensure all rare and priority species are known.	Prior to activities starting and throughout the project.	Conservation Commission CALM Serpentine-Jarrahdale Shire Alcoa Academia	6.1.1.3
13	Flora	Monitor known rare and priority flora species.	Ensure that thinning operations do not adversely impact rare and priority species.	Prior to activities starting and throughout the project.	Conservation Commission CALM Serpentine-Jarrahdale Shire Alcoa Academia	6.1.1.3

#	Topic	Actions	Objectives	Timing	Advice from	Report section
14	Flora	Ensure that dieback hygiene practices are implemented in all operations. Such as: • off-road access for machinery in dieback free areas restricted to dry-soil conditions; • bauxite pits and areas planted to exotics treated as 'uninterpretable' and appropriate cleandown required; • affected stands avoided and hygiene used to minimise risk of introduction into unaffected stands; • retained basal areas in jarrah stands above 15 m²/ha; • thinning preferred on site-vegetation types where <i>Phytophthora cinnamomi</i> is less favoured; • greater proportion of more tolerant species kept (such as marri) during tree-marking operations in areas where considered necessary; and • manage sites (if any) affected by <i>Armillaria luteobubalina</i>.	Minimise risk of dieback spread.	Throughout the project.	Conservation Commission CALM FPC	6.1.1.4 7.3



#	Topic	Actions	Objectives	Timing	Advice from	Report section
15	Flora	Retain key understorey species. Manage 'wheat-field' regeneration in keeping with natural conditions.	Keep understorey and overstorey in natural balance.	Throughout the project.	Conservation Commission CALM Serpentine-Jarrahdale Shire Alcoa Academia	5.2.3 7.1
16	Fauna	Identification and provision of fauna enhancement measures such as: • nesting boxes; • retention of habitat trees and logs; • key midstorey species; and • increased frequency of fox baiting.	No adverse impact on rare, threatened and vulnerable fauna and species protected under JAMBA–CAMBA.	Prior to activities starting and throughout the project.	Conservation Commission CALM Serpentine-Jarrahdale Shire Alcoa Academia	6.1.2.1
17	Fauna	Targeted searching and monitoring of key fauna species in the Wungong Catchment.	Understand diversity of fauna in catchment.	Prior to activities starting and throughout the project.	Conservation Commission CALM Serpentine-Jarrahdale Shire Alcoa Academia	6.1.2.1
18	Wetlands (rivers)	To maintain the integrity, ecological functions, environmental values and supply to downstream users of rivers.	Rivers and streams protected through the implementation of the informal reserve system.	Throughout the project.	Conservation Commission CALM DoE	5.2.1

#	Topic	Actions	Objectives	Timing	Advice from	Report section
19	Water (quantity)	Improve the quantity of water in streams (relative to rainfall) through the implementation of this project.	To maintain the quantity of water to existing and potential environmental and social values in the expected drying climate, including ecosystem maintenance and the water resource for the community.	Throughout the project.	Conservation Commission CALM FPC DoE Serpentine-Jarrahdale Shire Alcoa Academia Public	3.1
20	Water (quality)	Works undertaken in accordance with best-practice silvicultural prescriptions. Monitoring and management of the exposed soil of the steep slopes adjacent to Wungong Reservoir. Ensure the use of lowest drinking water quality risk option for thinning (glyphosate is currently used in notching or cut-stump operation).	Maintain water quality of Wungong Reservoir. No long-term increase in stream salinity. No long-term increase in turbidity in streams.	Throughout the project.	Conservation Commission CALM DoE	6.2 6.2.1 6.2.2
18	Wetlands (rivers)	To maintain the integrity, ecological functions, environmental values and supply to downstream users of rivers.	Rivers and streams protected through the implementation of the informal reserve system.	Throughout the project.	Conservation Commission CALM DoE	5.2.1



#	Topic	Actions	Objectives	Timing	Advice from	Report section
21	Land (terrestrial)	No major road construction to be undertaken. Implement informal reserve system to provide buffers beside streams.	To prevent significant erosion.	Throughout the project.		6.2.1
22	Conservation areas	Protection of areas as detailed in the Forest Management Plan (formal and informal reserves), as well as areas protected for water quality issues (100 m buffer around reservoir) and experimental control purposes (Waterfall Gully sub-catchment).	To protect the environmental values of areas identified as having significant environmental attributes.	Throughout the project.	Conservation Commission CALM DoE Alcoa Academia	5.2.1
23	Greenhouse gases	Investigate further the hypothesis that the impact of the project on greenhouse gases is neutral.	Determine the greenhouse gas impacts or benefits of catchment thinning as a water source.	Throughout the project.	Conservation Commission CALM Academia	6.3

#	Topic	Actions	Objectives	Timing	Advice from	Report section
24	Risk	Follow best-practice forest management including: • ensuring staff are trained and follow public safety procedures (such as signage around work areas); • consult with local community about operations; and • design silvicultural treatments to minimise fire risk (such as using cut-stump thinning rather than stem-injection near burn boundaries).	Ensure risk to surrounding community is as low as reasonably achievable and complies with acceptable standards and EPA criteria.	Throughout the project.	Conservation Commission CALM FPC Serpentine-Jarrahdale Shire Public	5.2.1
25	Recreation	Thin dense stands by no more than 50% in each stage. Ensure that forest adjacent to travel routes, walk trails and picnic areas is treated using the cut-stump thinning technique or are not thinned.	To maintain the visual amenity.	Throughout the project.	Serpentine-Jarrahdale Shire Public	6.4.1
26	Recreation	Investigate feasibility within the catchment of: • signage on walk trails; • guided tours; and • track work.	Manage recreation in the Wungong Catchment.	Prior to activities starting and throughout the project.	Serpentine-Jarrahdale Shire Public	6.4.2
27	Economics	Provision of a low-cost, safe 4–6 GL water source through the implementation of this project.	Fulfil the state water strategy commitments of a catchment management trial.	Throughout the project.		3.2.3

The 12-year Wungong Catchment management research project is expected to cost the Water Corporation approximately \$20 million.



Appendix 2 Forests compared

The forests around Perth are varied, although most are a relatively even structured regrowth jarrah forest (Figure 47.a). There are a range of methods for comparing different parts of the forest including leaf area index (LAI), basal area, diameter, age and silvicultural history. While regrowth and old growth forests (Figure 48) have similar basal areas, the regrowth forest has approximately four times as much circumferential length of conductive material per hectare than old growth and hence can use more water (as old growth trees are larger but there are less per hectare).

Examination of data provided by CALM which compared crown density between old growth and regrowth forest indicated a comparable value of 55% (Mattiske, E.M. and Associates, 2003). This data also showed 90% of these stands exceeded the basal area of 20 m²/ha. Various data showed stands that had been clear felled reached maximum density in 10–20 years.



(a) regrowth forest
LAI – 2.0
Basal area 35 m²/ha
Diameter 25 cm
60 years old
unthinned



(b) thinned rehab.
LAI – 0.5
Basal area 5 m²/ha
Diameter 15 cm
11 years old
thinned 1 month



(c) thinned native regrowth
LAI – 1.2
Basal area 11 m²/ha
Diameter 35 cm
60 years old
thinned 14 years ago
(to 7 m²/ha)



(d) thinned regrowth
LAI – 1.8
Basal area 25 m²/ha
Diameter 50 cm
80 years old
thinned 18 years ago



(e) old growth near Jarrahdale
LAI – 1.8
Basal area 35 m²/ha
Diameter 110 cm
200+ years old
unthinned

Figure 47 Diversity of the northern jarrah forest (Photos by Colin Terry)



(a) Jarrah forest near Jarrahdale 1895
(Dell et al., 1989)



(b) Jarrah forest near Jarrahdale 1896
(Power and Emberson, 1978)



(c) Jarrah forest along Karri Dale Road 1914
(Power and Emberson, 1978)



(d) Jarrah forest near Dwellingup 1926
(Power and Emberson, 1978)

Figure 48 Old growth jarrah forest a century ago



Appendix 3 27 September 2002 field trip

A field trip was held on 27 September 2002 in and around the Wungong Catchment near Perth. The day was about

- * information exchange - not decisions;
- * informed conversation; and
- * looking for solutions.

Before this field trip, the Water Corporation had held discussions with a number of groups on the topic of enhancing the environment and run-off in selected areas of Perth's surface water catchments (Table 8). People were invited to participate in informal discussion on techniques which may restore Nature's balance in our catchments. The field trip was an important part of the ongoing development of ideas and everyone's contribution was valued.

The agenda for the day was:

Item	Location	Facilitator	Topic
1	Canning Vale	Keith Barrett ¹	Welcome
2	In bus	Frank Batini ²	Overview
3	No.2 minesite	Carl Grant ³	Rehabilitation with jarrah and exotics, thinning trials, dieback forest rehabilitation
4	Stream	Kerry Trayler ⁴	Stream ecosystems
5	Old-growth	Joe Havel ²	Characteristics of old-growth stands
6	Mundlimup plots	Frank Batini ²	History and data, characteristics of regrowth and thinned stands
7	Dieback site	Frank Batini ²	History, hydrological effects, area affected
8	Gleneagle pines	Joe Havel ²	History, hydrological effects, options
9	Wungong Dam	Frank Batini ² & Keith Barrett ¹	Review

¹ Water Corporation, ² Water Corporation Consultant, ³ Alcoa, ⁴ Department of Environment

It is important to look first-hand at the current condition of our forested water catchments and together think about the management options available for their sustainable future. This field trip aimed to look at sites that are representative of different forest conditions (Figure 49). The facilitators were Frank Batini and Dr Joe Havel, both working as consultants for the Water Corporation, Dr Carl Grant from Alcoa, Dr Kerry Trayler from Department of Environment, and Keith Barrett from the Water Corporation.

The day started at 8:30 am for an 8:45 am departure in a bus (with one support vehicle), and finish at 5:05 pm, at the Water Corporation's regional office, 273 Bannister Road, Canning Vale. The group can be seen in Figure 3 at Wungong Dam (site 9), and in Figure 46 at the old-growth (site 5).

Wungong Catchment management project

A list of those invited and attending is given in Table 8.

Table 8 Invitees and attendees on September 2002 Wungong Catchment field trip

Name	Affiliation	Attended
John Gardner	Alcoa	no
Carl Grant	Alcoa	yes
Ken McIntosh	Alcoa	yes
Bernard Bowen	Environmental Protection Authority	yes
Jan Star	Serpentine-Jarrahdale Shire	yes
Sue Osborne	Serpentine-Jarrahdale Shire	yes
Peter Baldwin	Conservation Commission	yes
Rod Safstrom	Conservation Commission	yes
James Duggie	Conservation Council	yes
Phil Jennings	Conservation Council	no
Peter Robertson	Conservation Council	no
Beth Schultz	Conservation Council	yes
Graeme Rundle	Conservation Council	no
Gordon Wyre	Department of Conservation and Land Management	no
Caris Bailey	Department of Conservation and Land Management	no
Geoff Stoneman	Department of Conservation and Land Management	yes
Alan Sands	Department of Conservation and Land Management	no
Neil Burrows	Department of Conservation and Land Management	no
Mike James	Department of Industry and Resources and Chair MMPLG	no
Louis Bursztyrn	Department of Industry and Resources and Exec-officer MMPLG	yes
Pierre Horwitz	Edith Cowan University	no
Keith Low	Forest Products Commission	yes
Richard Hobbs	Murdoch University	yes
Mike Calver	Murdoch University	no
Jenny Davis	Murdoch University	no
Bernie Dell	Murdoch University	yes
Jane Madgwick	World Wildlife Fund for Nature	yes
Don McFarlane	Water and Rivers Commission	no
John Ruprecht	Water and Rivers Commission	yes
Kerry Trayler	Water and Rivers Commission	yes
Keith Barrett	Water Corporation	yes
Bob Humphries	Water Corporation	yes
Colin Terry	Water Corporation	yes
Mal Dennett	Water Corporation	yes
Graeme Hughes	Water Corporation	yes
Sally Robinson	Water Corporation consultant	yes
Libby Mattiske	Water Corporation consultant	yes
Frank Batini	Water Corporation consultant	yes
Joe Havel	Water Corporation consultant	yes

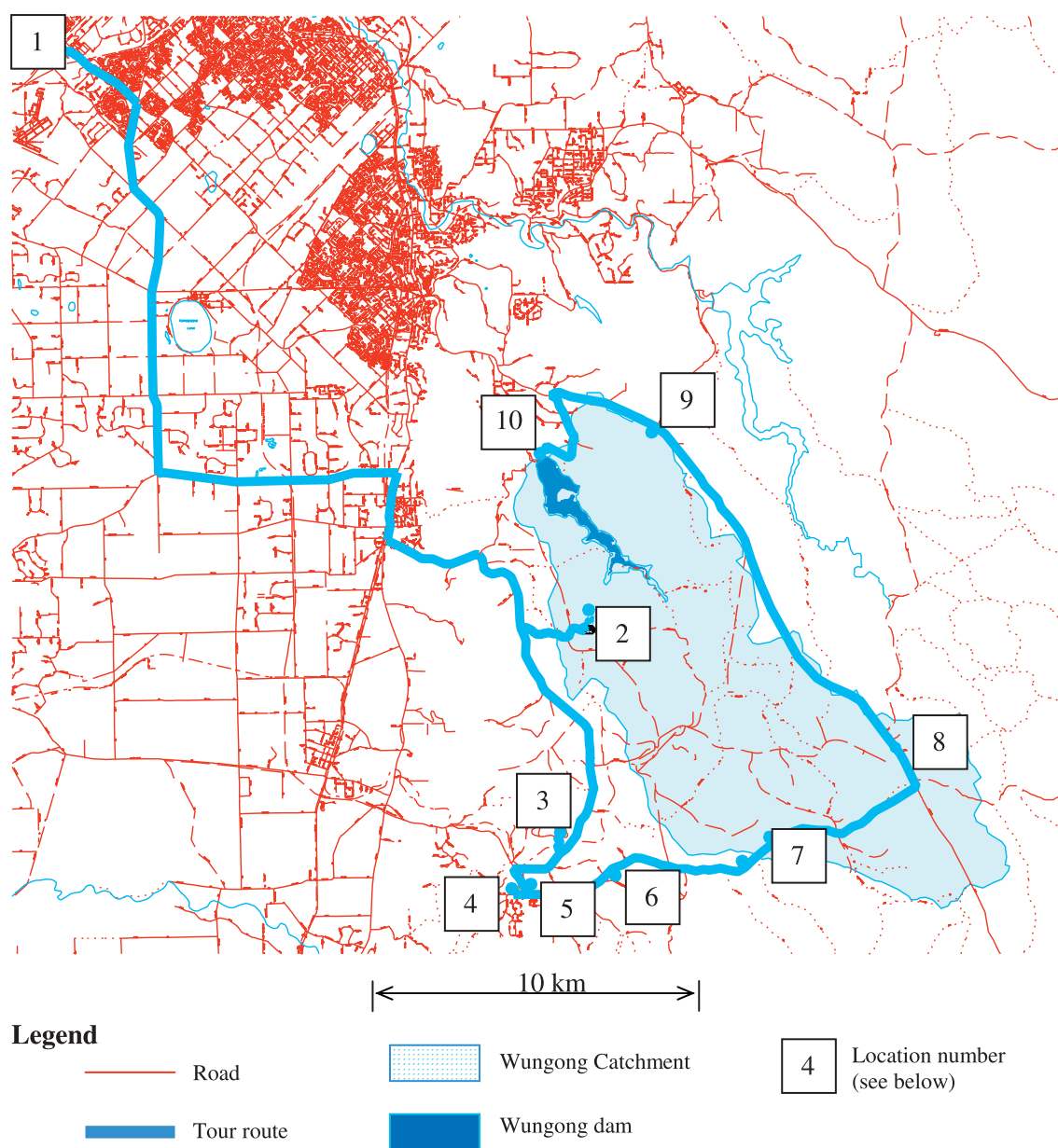


Figure 49 Map of Wungong Field Trip of 27 September 2002

Location number

1. Water Corporation's Canning Vale offices (start and end for day)
2. Alcoa's rehabilitation thinning trial and stream ecology near More Seldom Seen Creek
3. Langford Park (first mining rehabilitation)
4. Jarrahdale old growth (opposite cemetery)
5. Jarrahdale Tavern (lunch)
6. Mundlimup thinning plots
7. Dieback
8. Gleneagle pines
9. 1949 Dieback
10. Wungong Dam

Appendix 4 Summary of Forest Management Plan KPIs

The Forest Management Plan Key Performance Indicators (KPI) are directed at Department of Conservation and Land Management (CALM) managing the entirety of the State Forest, hence most of these KPIs are not directly applicable to the Wungong Catchment project. The Water Corporation will provide data for the applicable KPIs and develop its own project based ones (examples in Section 5.5.3). Below are listed the Forest Management Plan's KPIs and their interaction with the Wungong Catchment management project.

Biological Diversity

Key performance indicator 1	The representation of forest ecosystems in formal reserves.
Performance measure	Area of each forest ecosystem by land category (existing and proposed separately).
Performance target(s)	The Department and the Conservation Commission to complete all actions for which they are responsible in order to formally change the land category of areas proposed for the reserve system within 10 years after the commencement of the plan.
Reporting	Biennially on progress.
Response to progress shortfall	The Department to investigate lack of progress and report to the Conservation Commission and to the Minister for the Environment. The Department to address those impediments within its control and the Department and the Conservation Commission to advise the Minister for the Environment on measures to address other impediments.

This is a CALM management KPI. The Water Corporation is not proposing to treat areas within formal reserves or proposed formal reserves. The project does not involve changing reserves and the Water Corporation is not involved in the process of changing land categories.



Key performance indicator 2	The status of (critically endangered, endangered, vulnerable, conservation dependent) forest-dwelling species and ecological communities as determined by listing.
Performance measure	List of species and ecological communities and their status that tracks movements of species between protection categories.
Performance target(s)	No species or ecological community will move to a higher category of threat as a result of management activities.
Reporting	Annually with the review of the lists.
Response to progress shortfall	The Department to investigate the cause of a change to a more threatened category and report to the Conservation Commission and to the Minister for the Environment. The Conservation Commission to evaluate the need for revision of management practices, in the context of its assessment and auditing function, in consultation with the Department.

While this is a CALM KPI, this project will fall under the definition of 'management activity' in the performance target section. The Water Corporation will develop specific KPIs for the Wungong Catchment project.

Key performance indicator 3	The status of selected threatened or conservation dependent species that are the subject of management actions to protect them.
Performance measure	The trap success for animals at selected monitoring sites.
Performance target(s)	As per recovery plans.
Reporting	Annually.
Response to progress shortfall	The Department to investigate the cause and report to the Conservation Commission and to the Minister for the Environment. The Conservation Commission to evaluate the need for revision of management practices in the context of its assessment and auditing function, in consultation with the Department.

While this is a CALM KPI, the Water Corporation will collect data that may assist CALM's reporting.

Productive Capacity

Key performance indicator 4	The area of native forest and plantations.
Performance measure	Change in • the area of native forest and plantations; • area of forest by land category; • area of forest cleared; and • area of forest rehabilitated.
Performance target(s)	No permanent loss of net area of forested land.
Reporting	After each five years.
Response to progress shortfall	The Department to investigate the cause and report to the Conservation Commission and to the Minister for the Environment.

This is a CALM management KPI. The project does not involve changing the areas given in the performance measure. Although the Water Corporation plans to negotiate with Forest Products Commission (FPC) over converting the pines in the Gleneagle plantation to native species, there will not be a reduction in area of plantation if it does. Also approval will be required by CALM and FPC before exotic tree species in the mining rehabilitation can be converted to natives, as these are considered to be plantations.

Key performance indicator 5	Annual removal of wood products compared to the sustainable yield determined by the plan.
Performance measure	Cumulative removals for jarrah and karri first and second grade sawlogs compared to the average annual sustainable yield. • Annual removal of jarrah and karri sawlogs below first and second grade. • Annual removal of all logs.
Performance target(s)	• No more than 10% more than the average annual yield of first and second grade sawlogs of each species to be removed in any one year. • No more than 412 650 cubic metres of first and second grade jarrah sawlogs and 170 100 cubic metres of first and second grade karri sawlogs to be removed in any three consecutive years. • No more than 1 310 000 cubic metres of first and second grade jarrah sawlogs and 540 000 cubic metres of first and second grade karri sawlogs to be removed over the 10-year life of the plan. • Annual volume of jarrah and karri sawlogs other than first and second grade sold for value added products to show a positive trend.



	• No more than 13 000 cubic metres of wandoo, 16 000 cubic metres of blackbutt and 19 000 cubic metres of sheoak sawlogs to be removed over the 10-year life of the plan.
Reporting	Annually.
Response to progress shortfall	The Forest Products Commission to advise the Conservation Commission how it will manage removals to be under the end of plan target. The Conservation Commission to evaluate the need for a revision of harvesting levels in the context of its assessment and auditing functions, in consultation with the Department.

This is a CALM management KPI. Commercial wood products would be taken and reported by FPC.

Key performance indicator 6	Area of forest cut over annually.
Performance measure	Annual area of each forest type harvested according to each silvicultural objective.
Performance target(s)	Not possible to set a realistic target for area cut over.
Reporting	Annual publication of areas cut over.
Response to progress shortfall	The Conservation Commission to evaluate the need for revision of management practices in the context of its assessment and auditing function, in consultation with the Forest Products Commission and the Department.

This is a CALM management KPI. Water Corporation will develop a similar project KPI to ensure that the water increase benefits are obtained and report to CALM on the area treated for their KPI.

Key performance indicator 7	The removal of non-sawlog timber.
Performance measure	Total removals of firewood compared to the authorised removal through contract and licence.
Performance target(s)	Authorised removals more than 70% of estimated total removals based on survey information.
Reporting	After five years.
Response to progress shortfall	The Department to investigate the cause and report to the Conservation Commission and to the Minister for the Environment. The Conservation Commission to evaluate the need for revision of management practices in the context of its assessment and auditing function, in consultation with the Department.

This is a CALM management KPI. The Water Corporation's project is to not remove non-commercial (sawlog) material from the catchment.

Key performance indicator 8	The presence of <i>Sirex</i> in softwood plantations.
Performance measure	Evidence of <i>Sirex</i> in trap trees.
Performance target(s)	No evidence of <i>Sirex</i> in trap trees.
Reporting	Annually by the Forest Products Commission.
Response to progress shortfall	The Forest Products Commission to initiate a control program.

CALM and FPC manage this. The Water Corporation is not proposing to be involved in the management of softwood plantations. This project does include the conversion the Gleneagle pine plantation to native forest if an agreement can be reached with FPC. This project will not affect this KPI.

Key performance indicator 9	Time to regenerate harvested areas.
Performance measure	The time between completion of native forest harvesting of a coupe for regeneration and the completion of post-harvest regeneration treatment.
Performance target(s)	For karri and planted jarrah: • achieve more than 75% of areas treated to be completed within 18 months; and • achieve 100% of areas treated to be completed within 30 months. For other jarrah: • achieve 100% of areas treated to be completed within 18 months.
Reporting	Annually.
Response to progress shortfall	The Forest Products Commission to advise the Department how it will rectify the shortfall. The Department to determine the need for a revision of management practices, in consultation with the Conservation Commission.

FPC may decide to undertake commercial logging operation (harvesting) within the catchment, and as such are responsible for this KPI. The Water Corporation's non-commercial thinning will not effect this KPI.



Key performance indicator 10	Effectiveness of regeneration of native forest and plantation.
Performance measure	The proportion of the sampled annual regeneration release program that does not meet the standard set out in the Silviculture Guidelines.
Performance target(s)	No more than 5% of the area regenerated requiring remedial action.
Reporting	Annually.
Response to progress shortfall	The FPC to advise the Department how it will rectify the shortfall. CALM to determine the need for a revision of management practices, in consultation with the Conservation Commission.

Water Corporation is not proposing to undertake any forest regeneration release.

Key performance indicator 11	Forecast strategic timber yield versus actual timber yield.
Performance measure	The volume of timber removed in harvesting from monitoring plots against the volume predicted to be removed by the sustained yield calculation.
Performance target(s)	No target.
Reporting	At the mid-term (five years) review of the plan to allow for a reasonable number of plots to be measured in a range of strata to each silvicultural objective. The report to identify the size of the variation and the reasons for the variations.
Response to progress shortfall	The Conservation Commission to evaluate the need for revision of yield forecasting in the context of its assessment and auditing function, in consultation with the Department.

This is a CALM management KPI. Water Corporation's regular reporting to CALM would include the areas thinned and to what basal area.

Key performance indicator 12	The achievement of early thinning schedules that underpin future yield.
Performance measure	Achieved thinning versus that prescribed in silviculture schedules.
Performance target(s)	All stands thinned at the prescribed stand development stage.
Reporting	Two years after commencement of the plan and each two years thereafter.
Response to progress shortfall	The Forest Products Commission and the Department to investigate the cause and report to the Conservation Commission. The Conservation Commission to evaluate the need for revision of management practices in the context of its assessment and auditing function in consultation with the Department.

This is a CALM management KPI. While the project involves thinning, the Water Corporation is not responsible for thinning schedules in State Forest. Areas thinned, how, and to what density will be included in regular reporting to CALM. This project will assist them with this KPI.

Key performance indicator 13	Direct and indirect employment in the timber industries.
Performance measure	The numbers employed in native timber harvesting, processing and downstream manufacture.
Performance target(s)	No target, trends to be reported.
Reporting	The Forest Products Commission to report biennially.
Response to progress shortfall	The Department to investigate the cause and report to Conservation Commission and to the Minister for the Environment.

This is a FPC KPI, however, the Water Corporation will develop a similar KPI that specifically relates to this project.

Key performance indicator 14	Access for apiculture.
Performance measure	The number of registered sites by land category.
Performance target(s)	No target, trends to be reported.
Reporting	Biennially.
Response to progress shortfall	The Department to investigate the cause and report to Conservation Commission and to the Minister for the Environment. The Conservation Commission to evaluate the need for revision of management practices in the context of its assessment and auditing function, in consultation with the Department.

This is managed by CALM. While this project may involve feral bee control, it should not affect the number of sites registered for apiculture (i.e. this control is expected to manage the spread of feral bees and their impact, rather than limiting the access for apiculture).

Key performance indicator 15	Wildflowers and seed picking.
Performance measure	The level of activity measured by picking endorsements and returns.
Performance target(s)	No target, trends to be reported.
Reporting	Annually.
Response to progress shortfall	The Department to investigate the cause and report to Conservation Commission and to the Minister for the Environment. The Conservation Commission to evaluate the need for revision of management practices in the context of its assessment and auditing function, in consultation with the Department.

This project will not affect this KPI.



Ecosystem Health and Vitality

Key performance indicator 16	The risk to conservation, life, property and other forest values posed by wildfire.
Performance measure	The area of forest by fuel age classification.
Performance target(s)	Target to be determined following the Environmental Protection Authority review of fire management.
Reporting	Annually.
Response to progress shortfall	The Department to evaluate high-risk areas and incorporate into fuel reduction planning for subsequent years.

Fire management is undertaken by CALM. This project will involve the use of fire but will require the agreement of CALM and will be undertaken by them.

Key performance indicator 17	The severity status of weeds and pests as determined by subjective survey.
Performance measure	List of important weeds and pests and their severity status that tracks movements of species between severity categories.
Performance target(s)	No weed or pest to increase in severity status as a result of management actions.
Reporting	Every five years.
Response to progress shortfall	The Department to investigate the cause and report to the Conservation Commission and to the Minister for the Environment. The Conservation Commission to evaluate the need for revision of management practices in the context of its assessment and auditing function, in consultation with the Department.

The Water Corporation will not be involved in the development of this list. However, the management of weeds in the Wungong Catchment may be included as part of the additional environmental benefit program and therefore may have a positive impact on this performance target.

Key performance indicator 18	The effectiveness of dieback hygiene.
Performance measure	The number of sampled areas uninfested with <i>Phytophthora cinnamomi</i> that remain uninfested following an operation with an approved hygiene management plan.
Performance target(s)	No uninfested protectable area to become infested as a result of management actions.
Reporting	After five years. Results for State forest and timber reserves, and conservation reserves to be reported separately.
Response to progress shortfall	The Department to investigate and report to the Conservation Commission and to the Minister for the Environment. The Conservation Commission to evaluate the need for revision of management practices in the context of its assessment and auditing function, in consultation with the Department.

Dieback mapping for uninfested protectable areas will be described in the monitoring section of the management plan (developed after approval), with results reported to CALM for this KPI.

Soil and Water

Key performance indicator 19	The annual flow weighted mean salinity and the trend for streams in fully forested catchments.
Performance measure	The annual flow weighted mean salinity and the trends for gauging stations on the following rivers: Mitchell River (603005) Weld River (606002), (606195) Carey Brook (608002) Barlee Brook (608151) Harvey River (613002) Tallanalla Creek (613005) Falls Brook (613008) South Dandalup (614007) Little Dandalup (614017) Wilson Brook (614021)
Performance target(s)	Salinity trends to be neutral.



Reporting	Every five years subject to information being provided by the Water and Rivers Commission.
Response to progress shortfall	The Department to investigate the cause and report to the Conservation Commission and to the Minister for the Environment. The Conservation Commission to evaluate the need for revision of management practices in the context of its assessment and auditing function, in consultation with the Department.

The performance measure rivers will not be directly applicable to this project, but similar targets including turbidity will be developed for streams in the Wungong Catchment (in addition to NHMRC drinking water guideline monitoring of raw water from Wungong Dam as part of normal Water Corporation operations).

Key performance indicator 20	Percentage of water bodies (e.g. stream kilometres, lake hectares) with significant variance of biodiversity from the historic range of variability.
Performance measure	The diversity of aquatic macro-invertebrate fauna at a selected number of monitoring sites.
Performance target(s)	No sites with fauna significantly different from the reference condition.
Reporting	Every five years.
Response to progress shortfall	The Department to investigate the cause and report to the Conservation Commission and to the Minister for the Environment. The Conservation Commission to evaluate the need for revision of management practices in the context of its assessment and auditing function, in consultation with the Department.

Wungong Catchment management project specific KPIs will be developed, and are expected to pick two indicative fauna species and measures of aquatic invertebrate health (e.g. biomass and ratio of functional groups such as prey and predators).

Key performance indicator 21	The level of soil damage resulting from timber harvesting.
Performance measure	Soil damage by risk category as measured by survey.
Performance target(s)	Soil damage not to exceed prescribed maximum levels.
Reporting	Annually.
Response to progress shortfall	The Department to investigate the cause and report to the Conservation Commission and to the Minister for the Environment. The Conservation Commission to evaluate the need for revision of management practices in the context of its assessment and auditing function, in consultation with the Department.

Any timber harvesting (of commercial sawlogs) will be done by FPC. A separate KPI for the impact on soil from the proposed non-commercial thinning will be investigated as part of the development of KPIs.

Key performance indicator 22	Water production.
Performance measure	Streamflow of selected forest streams.
Performance target(s)	Streamflow to be maintained.
Reporting	Every five years subject to information being provided by the Water Corporation and the Water and Rivers Commission (linked to KPI 19).
Response to progress shortfall	The Department and the water authorities to identify the reasons for the trend and the Department to report to the Conservation Commission and to the Minister for the Environment. The Conservation Commission to evaluate the need for revision of management practices in the context of its assessment and auditing function, in consultation with the Department.

This is not directly applicable for the same reasons as for KPI 19. A separate KPI for water quantity in the Wungong Catchment will be developed.



Natural and Cultural Heritage

Key performance indicator 23	The identification and protection of cultural heritage.
Performance measure	The number of existing and new heritage sites identified in management planning and the number protected.
Performance target(s)	No disturbance of a registered place without formal approval.
Reporting	Annually.
Response to progress shortfall	The Department or the Forest Products Commission to investigate the cause and report to the Conservation Commission and in the case of the Department, to the Minister for the Environment. The Conservation Commission to evaluate the need for revision of management practices in the context of its assessment and auditing function, in consultation with the Department.

This KPI is applicable and the Water Corporation will identify and report heritage sites and protect them if they exist in the Wungong Catchment.

Key performance indicator 24	Consultation and involvement of Aboriginal people in forest management.
Performance measure	Establishment of the Nyoongar working group. Issues addressed by the Nyoongar working group. Statutory referrals required under native title legislation.
Performance target(s)	Nyoongar working group to be established by 31 December 2004. All statutory referrals made.
Reporting	Annually.
Response to progress shortfall	The Department or the Forest Products Commission to investigate the cause and report to the Conservation Commission and in the case of the Department, to the Minister for the Environment. The Conservation Commission to evaluate the need for revision of management practices in the context of its assessment and auditing function, in consultation with the Department.

This is directly applicable to CALM and the Forest Management Plan. Water Corporation will consult with local Aboriginal people, via the South-West Aboriginal Land and Sea Council, and others where appropriate.

Key performance indicator 25	The protection of heritage places through representation in reserves.
Performance measure	Representation of heritage values in the existing and proposed formal and informal reserve system.
Performance target(s)	The Department and the Conservation Commission to complete all actions for which they are responsible in order to formally change the land category of areas proposed for the reserve system within 10 years after the commencement of the plan.
Reporting	Biennially on progress.
Response to progress shortfall	The Department to investigate the lack of progress and report to the Conservation Commission and to the Minister for the Environment. The Department to address those impediments within its control and the Department and the Conservation Commission to advise the Minister for the Environment on measures to address other impediments.

The Water Corporation is not involved in the allocation of reserves. This project does not involve any treatment in informal or formal reserves.

Socio-economic Benefits

Key performance indicator 26	Number, range and use of recreation/tourism activities available by proposed land category in the plan area.
Performance measure	Type and number of recreation and tourism facilities available in the plan area (e.g. picnic sites, campsites, toilets, visitor centres, walking trails, or major tourism developments). The number of visits to selected recreation areas. The satisfaction visitors express with their experience.
Performance target(s)	Visitor satisfaction maintained at high levels.
Reporting	Annually.
Response to progress shortfall	The Department to investigate the cause and report to the Conservation Commission and to the Minister for the Environment. The Conservation Commission to evaluate the need for revision of management practices in the context of its assessment and auditing function, in consultation with the Department.

This is a CALM management KPI. The Water Corporation will report any changes to recreation facilities to CALM (which could include signage of walk trails and guided tours).



Key performance indicator 27	Basic raw material supply.
Performance measure	The number of notices of entry served to the Department under the Local Government Act.
Performance target(s)	No target, trends to be reported.
Reporting	Annually.

This project will not affect this KPI as water is not considered a basic raw material under the Forest Management Plan.

Plan Implementation

Key performance indicator 28	Adaptive management.
Performance measure	The number and topic of formal adaptive management trials.
Performance target(s)	Within five years, trials will be held into at least two separate issues detailed in the plan's action statements.
Reporting	Five years.
Response to progress shortfall	Department to report to the Conservation Commission and to the Minister for the Environment on measures required to address achievement.

This is a CALM management KPI. The Wungong Catchment project is an adaptive management trial and will be reported to CALM.

Key performance indicator 29	Provide for public involvement activities and public education, awareness and extension programs and make available forest-related information.
Performance measure	Compilation of programs for public involvement, education, awareness and extension programs.
Performance target(s)	Available programs and numbers of the community exposed to programs increases over time.
Reporting	Annually.
Response to progress shortfall	The Department to investigate the cause and report to the Conservation Commission and to the Minister for the Environment.

This KPI is directed at CALM, but a similar KPI will be developed for this project's reporting and consultation.

Key performance indicator 30	Develop and maintain human resource skills across relevant disciplines.
Performance measure	The extent to which the Department demonstrates the capacity and commitment to develop and maintain the essential skills of staff.
Performance target(s)	Persons responsible for undertaking key tasks on average meet 80% of the competency requirements for key tasks indicated in the environmental management system.
Reporting	Annually.
Response to progress shortfall	The Department and the Forest Products Commission to investigate the cause and report to the Conservation Commission and in the case of the Department, to the Minister for the Environment.

This KPI specifically relates the staffing competencies within CALM. The Water Corporation sees this project as a means to improve its understanding of forest management practices and therefore facilitate better communication between the Water Corporation and CALM. However, this project will not affect this KPI.

Key performance indicator 31	Development of scientific understanding of ecosystem characteristics and functions.
Performance measure	Expenditures on research and development related to ecologically sustainable forest management; Person years of scientific research, by ecosystem or disciplinary area of study, in the field of ecologically sustainable forest management; and/or Number of peer-reviewed articles published annually on ecologically sustainable forest management.
Performance target(s)	No target.
Reporting	Annually.
Response to progress shortfall	The Conservation Commission to review the scientific effort in forests in relation to the total Departmental effort and discuss priorities with the Department.

This KPI is specifically directed at CALM. However, a similar KPI will be developed for the Water Corporation's research project.



Key performance indicator 32	Environmental management system.
Performance measure	Development of a CALM environmental management system (EMS) to a standard suitable for accreditation.
Performance target(s)	EMS to be developed by December 2005.
Reporting	December 2005.
Response to progress shortfall	The Department to report to the Conservation Commission and to the Minister for the Environment on measures it proposes to complete the task and the completion date.

The Water Corporation has an Environmental Management System to ISO 14001 standard which will be applied to this project.

Key performance indicator 33	Operational control.
Performance measure	The extent to which guidance documents have been prepared/reviewed and management modified to improve ecologically sustainable forest management.
Performance target(s)	All guidance documents referred to in the actions proposed by the plan to be prepared/reviewed by mid-term.
Reporting	Annually.
Response to progress shortfall	The Department to investigate the cause and report to the Conservation Commission and to the Minister for the Environment. The Conservation Commission to evaluate the need for revision of management practices in the context of its assessment and auditing function, in consultation with the Department.

This is undertaken by CALM and this project will not affect this KPI. However, as a key stakeholder in how our forested catchments are managed, the Water Corporation provides input in the development of the guidance documents.

Appendix 5: Summary of Informal Reserves

The informal reserve system is identified in Appendix 3 of the Conservation Commission's Forest Management Plan 2004–2013 and is summarised in Table 9 with relevance to the Wungong Catchment.

Table 9 Relevance of Forest Management Plan informal reserve system to Wungong Catchment

Informal reserve type	Purpose	Criteria for inclusion in the Department's corporate database	Relevance to Wungong Catchment
Old-growth forest	Protect areas of old-growth forest outside the formal reserve system.	Areas greater than two hectares of ecologically mature forest, where the overstorey is in a late mature to senescent growth stage, and where the effects of disturbance (e.g. dieback, timber production, grazing) are either absent or now negligible.	From CALM's forest type information there is only a small patch of old-growth forest that is located within the proposed national park. Therefore this reserve type will not be impacted by the project.
Areas previously classified as old-growth forest	To protect and retain these areas as informal reserves despite their reclassification from old-growth forest.	Areas in the corporate database classified as old-growth forest on the commencement of the plan that are subsequently determined not to be old-growth forest or any other type of informal reserve.	As above.
River and stream zones	Provide forest undisturbed by timber harvesting. Protect water quality. Protect aesthetic and social values. Protect productive capacity, soil values and carbon pools.	A 60 m wide corridor in the area of first, second and third order streams, with all boundaries being at least 20 m from the bank of the stream. A 150 m wide corridor in the area of fourth order streams, with all boundaries being at least 50 m from the bank of the stream. A 400 m wide corridor in the area of fifth order streams, and streams of any higher category, with all boundaries being at least 100 m from the bank of the stream.	The project includes the protection of the stream zones as detailed (see Figure 18).



Informal reserve type	Purpose	Criteria for inclusion in the Department's corporate database	Relevance to Wungong Catchment
Travel route zones	Protect aesthetic and social values.	A corridor that extends at least 200 m from each side of Level 1 travel routes in the Warren region. A corridor that extends at least 100 m from each side of Level 2 travel routes in the Warren region. A corridor that extends at least 200 m from each side of the Bibbulmun Track.	The Wungong Catchment is not in the Warren region, and the Bibbulmun Track does not pass through or within 200 m of the catchment boundary. However the Water Corporation has made special provision for 200 m corridors around the Albany Highway, Jarrahdale Rd and the Munda Biddi bike track.
Diverse ecotype zones (DEZ)	Protect sensitive ecosystems.	Rock outcrops greater than 0.2 hectares and wetlands, heath, sedge, herb and low density woodland communities. All zones to incorporate a buffer of undisturbed vegetation around them. Ecological characteristics will be used to determine the boundary of these zones. DEZ are defined in CALM's corporate database by vegetation codes.	All rocky outcrops and non-forest areas as identified on CALM's forest type database will be protected with a 50 m buffer (beginning at change in vegetation). See Figure 18 for location of DEZ in the Wungong Catchment.

Informal reserve type	Purpose	Criteria for inclusion in the Department's corporate database	Relevance to Wungong Catchment
Less well reserved vegetation complexes	Provide additional protection for the less well reserved vegetation complexes that occur on State forest and timber reserves available for timber harvesting.	Vegetation complexes that have either i. less than five per cent of their pre-European area in existing or proposed formal and informal reserves; or ii. between five and 10 per cent of their pre-European area in existing or proposed formal and informal reserves and less than 15 per cent of their pre-European area remaining.	The vegetation complexes that are identified in Appendix 3 of the Forest Management Plan are not within the boundary of the Wungong Catchment (see Figure 38 for vegetation complexes in the Wungong Catchment).
Poorly reserved forest ecosystem	Provide additional protection for a poorly reserved forest ecosystem that occurs on State forest and timber reserves available for timber harvesting.	Darling Scarp forest ecosystem that has less than 15 per cent of pre-European area in existing or proposed formal plus Comprehensive and Adequate Representative informal reserves.	The Wungong Catchment is not located on the Darling Scarp, therefore the project will not affect this reserve type.
Regional Forest Agreement accredited linkage zones	Provide low disturbance linkage zones.	The areas identified in the Department's corporate database that provide a link between the proposed Milyeanup National Park and an adjacent stream zone, and a corridor between the Helena and Flynn parts of the proposed Helena Valley National Park.	The Wungong Catchment is not located in this area.



Appendix 6: Herbicide water quality risk assessment

The techniques for catchment thinning have evolved over the last century to cull trees, with current best practice using glyphosate (sold as Roundup) as part of a notching or cut-stump operation. Glyphosate is a herbicide approved for use in drinking water catchments provided that it is the lowest water quality risk option, which is what this analysis will confirm. From other points of view glyphosate is low cost and less dangerous for people and the environment than other herbicides. It has been widely used safely by many organisations over many years for weed control and forest thinning.

Herbicides are used to stop trees from coppicing once they are cut down or to kill them while still standing. Without coppicing control, the benefits of catchment

thinning are relatively short lived. There are alternative methods that could theoretically be used:

- ❖ Ring barking or falling trees which does not control coppicing – so frequent manual control would be required involving many more people accessing the catchment;
- ❖ Pulling trees and their stumps out which would stop coppicing – but require large equipment and be very invasive.

A comparison of catchment thinning options is given in Table 10 using the Water Corporation's risk-based framework (see Table 11 to Table 14 for an explanation of terms).

Table 10 Water quality risk assessment for catchment thinning options

Land-use/Activity	Use of glyphosate for catchment thinning			Ring barking and manual coppice control	Falling tree and manual coppice control	Pulling tree and stump out	
Hazard Event/Source	Application on plants being washed into stream	Spillage during pack refill flowing into stream	Accident resulting in discharge into stream or water body	Pathogens from human waste during frequent intervention	Pathogens from human waste during frequent intervention	Erosion from large scale intervention	
Hazard	Herbicide	Herbicide	Herbicide	Biological	Biological	Turbidity	
Consideration for likelihood	Quantity scenario	0.5 L	5 L	20 L	0.5 L	0.5 L	100 kg
	Distance to stream	Min 30 m	Min 30 m	0 m	Min 30 m	Min 30 m	Min 30 m
Maximum likelihood	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely	Likely	
Severity	Negligible	Negligible	High	High	High	High	
Maximum Risk	Trivial	Trivial	Significant	Significant	Significant	High	
Current Catchment Preventive Strategies	CALM procedures Non-rainy day	CALM procedures Distance from streams	Driver training & awareness	CALM procedures Hygiene	CALM procedures Hygiene	CALM procedures Dry soil operation	

– CONTINUED NEXT PAGE

Table 10 Water quality risk assessment for catchment thinning options

– CONTINUED

Land-use/Activity	Use of glyphosate for catchment thinning			Ring barking and manual coppice control	Falling tree and manual coppice control	Pulling tree and stump out
Hazard Event/Source	High	High	High	Medium	Medium	Low
Considerations	Low-risk herbicides	Low-risk herbicides	Low-risk herbicides	Summer operation	Summer operation	Summer operation
Residual Likelihood	Rare	Rare	Rare	Possible	Possible	Possible
Residual Risk	Trivial	Trivial	Moderate	Significant	Significant	Major

In conclusion, the management priority for concern about using glyphosate is low, while other techniques are riskier and have a medium priority.

Table 11 Likelihood Scale

Likelihood	
Almost Certain	Is expected to occur in most circumstances
Likely	Will probably occur in most circumstances
Possible	Might occur at some time
Unlikely	Could occur at some time
Rare	May occur only in exceptional circumstances
<i>Source: Water Corporation Sanitary Assessment Guidance Manual, Egis Consulting Australia, 2000</i>	



Table 12 Severity Scale

Severity	
Extreme	The consequences would threaten the survival of not only the activity, but also the Water Corporation, possibly causing major problems for clients and for much of the Western Australian public sector
High	The consequences would threaten the survival or continued effective operation of the activity or project, or attract adverse media attention and require top level management or ministerial intervention
Medium	The consequences would not threaten the activity, but would mean that the activity could be subject to significant review or changed ways of operating
Low	The consequences would threaten the efficiency or effectiveness of some aspect of the activity but would be dealt with internally
Negligible	The consequences are dealt with by routine operations
Source: <i>Water Corporation Sanitary Assessment Guidance Manual, Egis Consulting Australia, 2000</i>	

Table 13 Level of Risk Scale

Likelihood	Severity				
	Extreme	High	Medium	Low	Negligible
Almost Certain	Severe	Severe	High	Major	Trivial
Likely	Severe	High	Major	Significant	Trivial
Possible	High	Major	Significant	Moderate	Trivial
Unlikely	Major	Significant	Moderate	Low	Trivial
Rare	Significant	Moderate	Low	Trivial	Trivial
Source: <i>Water Corporation Sanitary Assessment Guidance Manual, Egis Consulting Australia, 2000</i>					

Table 14 Management Priority Scale

Management Priority	Level of Risk
High	Severe or High
Medium	Major or Significant
Low	Moderate or Low or Trivial

Wungong Catchment management project



Wungong
Catchment
management
project



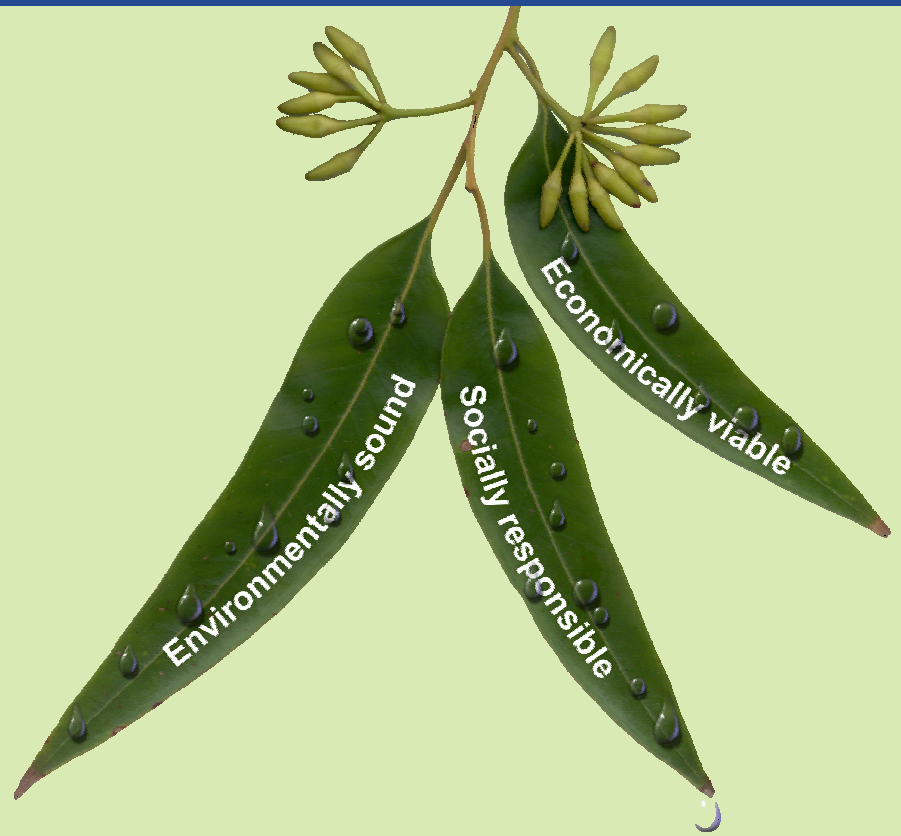


Colin Terry, 2003

Trees and water are part of the same environment and should be considered together.



Wungong Catchment Environment and Water Management project



**Water Corporation response to
submissions from 2005 public review**

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This document and other information including the project document is also available on the Water Corporation's Internet web-site at:

<http://www.watercorporation.com.au/wungong/>

(under 'environment and community > environmental programs > Wungong Catchment project').

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Summary

A public review of the Wungong Catchment Environment and Water Management project was conducted by the Water Corporation for eight weeks from 26 April 2005 to 22 June 2005. The Environmental Protection Authority (EPA) will provide advice on this Wungong project to the Minister for the Environment after it considers issues raised in the original document, issues raised during the review period and the responses to them.

The aim of this public review was to further inform the community about the project, seek the community's ongoing involvement in the project and use the process to determine opportunities for improvement. The Water Corporation believes it was successful in all three areas with feedback enabling the following improvements to be made:

- changes to silvicultural prescriptions;
- refined focus for research topics that form part of the project's research program; and
- better program for the involvement of stakeholders in the project.

The review identified the community's preference for maintaining the existing ratio of jarrah to marri tree species during the non-commercial thinning of the native regrowth forest, and not undertaking thinning of jarrah to favour retention of more marri as planned in the original project document. This recommendation will be adopted during the thinning of the native regrowth forest.

The public review commenced with a Ministerial launch at Wungong Dam on 26 April 2005. Following this launch, extensive distribution of the project document was undertaken, with open days and public presentations conducted to allow the community to learn more about the proposal and to provide forums for open discussion. This review resulted in forty three written submissions from a combination of both private, government and community based organisations. Analysis of the submissions revealed that thirty five issues had been raised. The issues raised during the public review period related to potential impacts and benefits from the project, such as dieback, fire, rainfall change, water quality and quantity, flora and fauna, energy balance, social and timber products. There were also issues raised about management of the project including stakeholder involvement and decision-making during implementation of the project. The community was also interested in the ongoing management of the forest after this research project was completed. The key issues from the review are summarised below. The selection of these issues was based on environmental, social, economic and governance risks, and number of times the issues were raised in submissions.

I. Rainfall: Will thinning reduce rainfall?

As trees are an important conduit for water in the catchment water cycle, there was concern that reducing the number of trees in part of the Wungong Catchment may reduce rainfall. This concern is based on local observation of cloud formation over forests and less over non-forested areas, some impact on local rainfall from clearing 16 million hectares in the wheat belt, and impacts on rainfall in humid overseas catchments related to forest changes (e.g. species change or forest clearing). This project will operate in a small part of the landscape and also local Darling Range rainfall is dominated by rain fronts whose water originates in the Indian Ocean, not from transpiration from local vegetation. It is therefore expected that the project will have no measurable impact on rainfall, but as rainfall will be measured during the project at several stations inside and outside the catchment, it will be possible to monitor whether rainfall does change.

2. Salinity and chemicals in catchments: How will non-commercial thinning impact on stream salinity? Is Roundup® safe to use in drinking water catchments for catchment thinning?

Protecting water quality is paramount to the Water Corporation's charter. The Water Corporation would not proceed with a project that had a significant risk of increasing stream salinity or having unacceptable levels of herbicide entering a water storage. There are real problems with dryland salinity in lower rainfall areas due to a reduction in vegetation and problems with some herbicides, which raised concern that this project would degrade water quality as it is plans on reducing vegetation cover and using herbicides as part of the catchment thinning. Previous research of catchment thinning in south-west of Western Australia has demonstrated that there is minimal risk of increased salinity from thinning in the Wungong catchment which is in a higher rainfall area. In addition, the herbicide Roundup® which is to be used in the thinning operation, has been deemed safe for use in drinking water catchments by the Department of Health when used as planned. Roundup® breaks down quickly in the organic parts of soil and will be handled in small volumes to reduce the impact from any accidental spillage. In-stream water quality monitoring, using both automatic and manual water sample collection techniques, along with best practice chemical handling will be used to ensure the water quality is protected during the project. In the unlikely event of a major water quality problem, Wungong Dam's outflow to customers can be stopped quickly without compromising water services to customers.

3. Dieback: What is the expected impact of non-commercial thinning on the spread of dieback?

The project recognises some risk associated with dieback. Half of the catchment is affected by dieback. The individual plants already affected are most likely the more susceptible plants, with those remaining being more resistant to dieback. Past research linking bark moisture and spread of *Phytophthora cinnamoni* within wounded jarrah tissues, indicates the strongest driver for the spread was annual rainfall. The fungus works best in warm and wet soil conditions and is therefore not assisted by a drying climate. There is now much less evidence of recent deaths of highly susceptible species such as banksia within forest areas. Also in the wetter, lower parts of valleys where thinning is likely to increase soil moisture, the flora has already changed to more dieback resistant species. The surviving species on the lower slopes have survived there for some decades (with dieback recorded on aerial photos in the Wungong from about the 1940s) and under conditions of much higher rainfall than currently observed. Hence increasing soil moisture now from thinning is unlikely to increase dieback. The risk of introducing dieback by walking, which is the main method of accessing the forest during non-commercial thinning, is very low. The risk of spreading dieback can be reduced by implementing appropriate operational practices in the forest. The project will adhere to current management requirements in the Forest Management Plan including implementing dieback mapping, forest hygiene, operations in dry soil using light-weight vehicles and foot access and vehicle wash-down if required to minimise this risk.

4. Catchment thinning after this project and involvement in the project: What catchment thinning will occur after the Wungong project? Was the consultation during the project development and the public review adequate? How do people want to be involved during the project?

When Government, regulators and the community are satisfied that the Wungong project is successful in providing good environmental and water outcomes, then catchment thinning will be conducted in appropriate parts of other catchments. This work after the success of the Wungong project could provide an extra 40 gegalitre water source for the Integrated Water Supply Scheme, and would be conducted in stages over many years. Given the importance of this future water source and potential for improving the catchment environment, it is vital there is appropriate involvement during the project by those who will be considering the project's success. Public consultation on catchment thinning has occurred

in the early 1980s and since May 2002. This recent public review is another step to better inform and involve stakeholders and to help improve the project. The Water Corporation project manager is the key day-to-day decision maker for the project. The Corporation's executive will oversee this project and provide support to the Project Manager. The Water Corporation will seek ongoing stakeholder input throughout the life of the project. The Corporation will rely on stakeholder input for review before progressing through decision making points during the project. There will be numerous communication streams including a project web site, presentations, workshops and field trips, and potential participation in research and on-ground work. A community and research representative will be appointed to the project's Technical Reference Group. The community representative, probably selected from a community member of the Conservation Commission, must be able to contribute technically to the group. This public review is considered to be adequate to facilitate implementation of the Wungong project. It has built on three years of project consultation, confirmed most aspects of the project are environmentally appropriate and provides additional value adding information. Adequate ongoing opportunities will be provided for stakeholder and public review during the life of the project.

In general there were both positive and negative responses from the public review. As expected, there were more submissions from people and organisations who opposed the project, but there was also strong support from some submissions. Most submissions favoured parts of the project, such as treatments in the mining rehabilitated areas, and most concern was with thinning the native forest.

No fatal flaws were identified with the elements of the project during the review, including the thinning of the native regrowth forest. Non-commercial thinning of the native regrowth forest is a key part of the project and the Water Corporation will not proceed with this project without access to this part of the forest.

The Water Corporation believes this research project is necessary to test the hypotheses that there can be increased environment and water benefits in a drying climate from the catchment management in this project. In particular the forest will start be to moved towards a more mature structure without significant negative impact on fauna, flora and water quality, and streamflow will be increased by 25% (an extra 4–6 ggalitre per year when averaged over the 12-year project depending on rainfall). The project is designed to use adaptive management based on adequate monitoring and research, and it should proceed. Subject to the advice from the EPA to the Minister for the Environment, the on-ground work will start from spring 2005.

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Abbreviations

Used by Water Corporation or others in submission quotes

a	annum (same as year)
ARC	Australia Research Council
CALM	Department of Conservation and Land Management
CoAG	Council of Australian Governments
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DBP	disinfection byproducts
DDT	dichloro diphenyl trichloroethane
DoE	Department of Environment
EPA	Environmental Protection Authority
FPC	Forest Products Commission
FMP	Forest Management Plan
GL	gigalitre
ha	hectare (area of 10 000 m ²)
JAMBA–	Japan-Australia Migratory Bird Agreement –
CAMBA	China-Australia Migratory Bird Agreement
LCDC	Land Conservation District Committees
KPI	key performance indicator
m	metre
m ²	square metre
MMPLG	Mining and Management Program Liaison Group
NDVI	normalized difference vegetation index
NOM	natural organic matter
p	page
para	paragraph
PhD	Doctor of Philosophy
SLUI	Salinity and Landuse Impact (series of reports from DoE)
UWA	University of Western Australia
WA	Western Australia
Water Corp	Water Corporation
WCMPD	Wungong Catchment Management Project document
yr	year

Note: unless mentioned otherwise, all departments are Western Australian State Government.

1 Introduction

The Wungong Catchment Environment and Water Management project (Wungong project) is a 12-year research trial that includes catchment thinning in selected parts of the Wungong Catchment. The project document describing this project is available from the Water Corporation in hardcopy and on the project web-site (www.watercorporation.com.au/wungong).

The thinning, which has a non-commercial focus, will help move the forest towards a more mature structure based on fewer larger trees and allow extra water to reach the stream to benefit the environment and water storages. This project has been identified in the State Water Strategy released by the Premier in 2003 and is based on several decades of forest and catchment research which identified the need for further work to determine the environmental impacts of forests treatments to increase water yield. The State Water Strategy identified catchment thinning as a potentially large water source. It also identified the need for a trial as a first step. Past research of catchment thinning has demonstrated that thinning can produce extra run-off without impairing water quality, and scaling up to Wungong Catchment is the next step. Within the Wungong Catchment up to 62% of the catchment will be thinned to increase the spacing between trees from 3–4 m to 5–6 m, with a retained basal area of 15–18 m²/ha. Basal area is the cross-sectional area of trees in a particular plot measured at chest height. As part of the Wungong project, areas of introduced tree species will be gradually converted back to native species. In addition there are projects for additional environmental benefit plus monitoring, auditing research and communication with stakeholders.

The main activity of the project is catchment thinning, which has been designed to be consistent with the Government approved Conservation Commission of Western Australia's Forest Management Plan 2004–2013. The Environmental Protection Authority (EPA) have provided advice that this Forest Management Plan is environmentally acceptable, and in January 2005 the Conservation Commission and Department of Conservation and Land Management (CALM) stated that the Wungong project was consistent with this plan.

During the extensive stakeholder consultation by the Water Corporation from 2002–2004, described in the project document, the Water Corporation had committed to a public process for the Wungong project. If the community and stakeholders are going to develop a position on the level of success of this project, they need to be involved through the project. As the project has been deemed consistent with the Forest Management Plan that is approved by Government, the EPA decided it would not be appropriate to use Section 38 of the *Environmental Protection Act 1986* to assess the project as a new proposal. The EPA agreed to use Section 16 of the *Environmental Protection Act 1986* to provide advice to the Minister for the Environment on the project after the Water Corporation conducted a public review. The public review will assist the EPA and add to the feedback from stakeholders already incorporated in the project document.

This report describes the public review conducted by the Water Corporation from 26 April 2005 to 22 June 2005, summarises the issues raised, provides responses by the Water Corporation and provides an implementation plan for the project. The Water Corporation is grateful for the feedback provided and acknowledges the time and effort required to become involved and understand the Wungong project, and then to respond. Thankyou to everyone who made the effort to be involved during the review. It is estimated that collectively stakeholders spent more than 600 hours in being involved and participating in the public review. This effort has contributed to a more refined plan for the Wungong project.

This report is for the EPA and will be distributed to all those who made submissions during the public review. It will be made publicly available through the project's web-site. While consultation will be ongoing, this report concludes the formal opportunity for comment at this stage.

2 Project issues raised during public review and responses

The aim of the public review was to inform and involve stakeholders, and improve the project based on feedback. A key output of the review is a summary of the issues raised in the written submissions and responses to them. Another important output is a description of project's implementation (Section 3). These two outputs will be used by the EPA in writing their advice to the Minister for the Environment.

Following the launch of the Wungong project's public review on 26 April 2005 at Wungong Dam by Hon. John Kobelke, Minister Assisting the Minister for Water Resources, 43 written submissions were made. Most were directed to the Water Corporation, with 14 to the Minister or Premier. It was planned that the 6-week public review would close on 8 June 2005, but it was extended at the request of environmental groups for two more weeks until 22 June 2005.

The submissions ranged in length and detail from a paragraph to many pages. Some were supportive, others cautious and many unsupportive of major parts of the project. In general for those with concerns with the project, all supported the management of exotic or introduced tree species within the catchment, but did not want active management of the native regrowth forest.

The submissions were analysed and classified into thirty five issues, with responses made to each issue (Sections 2.1 to 2.35). Issues are described and responded to in a common framework of a five element table:

Issue	Issue posed as a question
Submission quotes	Samples of quotes from submissions which are not usually directly attributed to particular submissions, as the focus is on addressing issues. If several quotes are taken from the one submission they are put in the same paragraph. Where an organisation has regularity responsibility for an issue or considered by the public to be an expert on a technical issue, they are named. Comments in square brackets [] have been added editorially later for clarity.
Summary of issue	Summary of perceptions and views from submissions.
Response	Water Corporation response to submission issue.
Answer	Answer to the issue.

2.1 Project document

Issue	Was the project document adequate in explaining the Wungong project and what will happen after the project?
Submission quotes	"I found it very interesting and of professional standard, though there are some minor errors, such as Xanthorrhoea preish (preisii?) on p 38 and these taxon (taxa?) on p 65." "... omissions of some relevant references, in particular those relating to catchment management, photocopies of which I include." "it is beautifully put together and very informative, but lengthy!" "We acknowledge that you have produced a very well researched report in favour of this project"
Summary of issue	Although large, the project document was of a high standard with only minor typographical errors.
Response	Catchment management is complex and the length of the project document illustrates the number of issues that need explanation. A 6-page summary of the main document was produced and used in the public review, but submissions were directed appropriately at the main document. Future communications related to the project will continue to provide information at several levels of detail from thirty second television advertisements to scientific journal papers. The project document was adequate in explaining the project, but in just focusing on the 12-year project it did not provide enough information about the long-term vision for the forests in the Wungong Catchment. In the absence of this information some submissions have made incorrect assumptions. In particular some have assumed incorrectly the forest will be kept permanently at a basal area of 15–18 m²/ha, when in fact it will on average increase its basal area in time as it moves towards a more mature structure (Section 2.22).
Answer	Document was adequate and the public review process provided an opportunity to clarify some points of uncertainty.

2.2 Dieback

Issue	What is the expected impact of thinning on the spread of dieback?
Submission quotes	“[project document provides] inadequate linkage of treatment with dieback and site, which has a bearing on likely impact of thinning (most of the thinning will be on the less susceptible sites - Dwellingup rather than Yarragil, which is already largely dieback-affected and mostly in informal reserves).” “The operation of thinning increases the risk of disease introduction or spread, especially <i>Phytophthora cinnamoni</i>.” “There will permanently be less tree canopy so more rain and sunlight will reach the ground. This will provide ideal conditions for the introduction and spread of <i>Phytophthora</i> dieback.” “Research has shown that thinning forest in the intermediate rainfall zone causes <i>Phytophthora</i> dieback to infect the forest more readily and to spread more rapidly if it is already present. The proposal will increase the presence and intensity of this serious pathogen.” “Dieback is a major threatening process to biodiversity and the Water Corporation should pay much more attention to halting spread by preventive means and to long term research on dieback and its management in water catchments.” “How has dieback affected [water] yield?” CSIRO Land and Water “... [regrowth manipulation will] Increase the likely spread of dieback not only by the thinning operations but also by increased soil temperature through canopy reduction and promoting more aggressive spread from already infected areas.” “In the past, spread of Dieback in forest areas predominantly by loggers and by ALCOA workers has been widespread and is still continuing in spite off all wash down procedures and precautions. 4500 WA plant species are threatened by Dieback so any further spread of Dieback will necessarily threaten biodiversity. In all Dieback areas, these guidelines need to be strictly enforced, honored and reiterated.”
Summary of issue	• Dieback has the potential to spread due to thinning. • Dieback is a major threat to biodiversity and management guidelines need to be followed. • Spread of dieback is unlikely, as thinning will occur on less susceptible sites.
Response	The project recognises some risk associated with dieback. Half of the Wungong Catchment is already infected by dieback. The individual plants affected are most likely the more susceptible plants, with those remaining being more resistant to dieback. Past research linking bark moisture and spread of <i>Phytophthora cinnamoni</i> within wounded jarrah tissues indicates the strongest driver for the spread was annual rainfall. The fungus works best in warm and wet soil conditions and is therefore not assisted by a drying climate. There is now much less evidence of recent deaths of highly susceptible species such as banksia within forest areas. Also in the wetter, lower parts of valleys where thinning is likely to increase soil moisture, the flora has already changed

	to more dieback resistant species. The surviving species on the lower slopes have survived there for some decades (with dieback recorded on aerial photos in the Wungong from about the 1940s) and under conditions of much higher rainfall than currently observed. Hence increasing soil moisture from thinning now is unlikely to increase dieback. The risk of introducing dieback by walking is very low, if the disease is not present and is not introduced, thinning will not increase the risk. Past research in the Wungong Catchment has shown that dieback will substantially increase streamflow because it is a long term change to the forest canopy. Since death is induced by drought stress, increased soil moisture should assist tree survival. In to the future, catchment thinning will reduce the water stress to trees in a drying climate, allowing them to better cope with a range of conditions, including dieback. From a management perspective, the risk of spreading dieback can be reduced by actions such as dieback mapping, hygiene, conducting forestry operations in dry soil, using light-weight vehicles, foot access and vehicle wash-down if required, between dieback free and infested sites.
Answer	With the appropriate hygiene, there is not expected to be an impact on dieback spread due to thinning, because of the vegetation changes that have already occurred due to dieback, especially on the lower slopes where in the catchment thinning will increase soil moisture and because there is a drying climate.

2.3 Fire

Issue	Should fire be part of catchment management?
Submission quotes	“Burning to increase runoff is not environmentally acceptable. CALM already has many pretexts to burn forest and bushland too often for the health and survival of natural ecosystems. We should not give it another pretext to burn forest frequently for reasons that have nothing to do with protecting and conserving biodiversity.” “Logging is a severe disturbance in a forest. Burning is another severe disturbance. To log then burn is to impose two severe disturbances on the forest in quick succession, which would rarely if ever happen under natural conditions. Ecologically sustainable forest management requires human-caused disturbance to be within the bounds of natural disturbance. So logging plus burning is not ecologically sustainable forest management.” “Fire makes soil water-repellent, so prescribed burning may prevent water penetrating into the soil. This may well increase deaths from drought stress in an already drought-stressed environment.” “When the killed trees dry out, whether standing or on the ground, they will create a serious fire hazard and fuel an intense wildfire that could kill the retained ‘crop’ trees.” “Ecologically sustainable forest management requires human-caused disturbance to be within the bounds of natural disturbance regimes (Lindenmayer, D.B., and J.F Franklin, 2002. Conserving forest biodiversity. Washington, DC. Island Press). So logging plus burning is not ecologically sustainable forest management.” “We note the extensive use of burning and practices such as scrub rolling proposed to reduce fire risk. These have detrimental effects on biodiversity.” “In a drier and hotter climate, fire risk will increase and this needs to be recognised. With large numbers of killed trees left standing after thinning, presumably the risk of more intense fire in more standing dead wood will be even greater. Excessive burning depletes biodiversity values significantly, and for this reason we do not support the concept of a partly dead standing forest. In the event of heavy rains soon after prescribed burning or major fires leaving a bare landscape, surface runoff rates and erosion would be high. Any chemicals used or their breakdown products could be rapidly transported to streams and the reservoir. This is an unsatisfactory situation and should be prevented by avoiding use of chemicals. Such a string of events has occurred in Tasmania resulting in extensive ecological damage where areas have been sprayed under ‘forest management practices’ and then burnt” “After the wet season, ground litter and dried vegetation ought to be regularly burned to assist with the generation of new growth and to minimise excessive build up of fuel resulting in uncontrolled intensely hot fires.” “... [regrowth manipulation will] Create an additional standing fuel load when poisoned trees dry out. Under the right conditions this additional fuel will promote severe crown scorch or crown fire which creates severe wildfire conditions that will kill the retained ‘crop’ trees.” “Even though we are NOT advocating that the trees are logged and removed from the area, we do have concerns that the dead trees will increase the risk of a hotter fire, possibly becoming a wildfire (and kill the retained trees). This might encourage CALM to want to burn off more frequently, which will also

	reduce biodiversity, over time reducing the flora to only fire tolerant species. Any reduction in biodiversity in flora necessarily results in a reduction in fauna species.”
Summary of issue	• Burning and logging together is not ecologically sustainable forest management because it is outside the bounds of natural disturbance. • Thinning will increase the intensity of wildfire. • Spring prescribed burning will promote regeneration and minimise chance of uncontrolled fires being intense.
Response	Fire is a natural phenomenon in forested catchments: it is a creator, destroyer and protector. A recent EPA review of the Department of Conservation and Land Management’s (CALM) fire management has been endorsed by the Minister for the Environment. While there are some areas identified for improvement including the need to formalise public involvement in the 3-year indicative burning plans, the EPA’s advice was positive about current fire management practices. The Wungong project will use current best-practice fire management as part of catchment management. From a water perspective prescribed burning has benefits with a temporary increase in run-off and by decreasing fuel loads it decreases the intensity and assists with control of wildfires. Mild prescribed burning will reduce the risk of more intense bush fires that severely damage the environment and cause water quality problems. An example of this is the impact on Mundaring Catchment’s environment and water quality after the Perth hills bushfires in mid-January 2005. It is clear by looking at the on-ground impact of the fire and from remote sensing analysis showing intensity of the fire that prescribed burning in the recent past has reduced the extent and intensity of the bushfire. Most of the area burnt in the wildfire had not been prescribed burnt recently, and damage to the vegetation resulted in poor water quality after rainfall. With intense fires the soil properties can be changed to make them water repellent, which can lead to erosion problems. Thinning and some scrub rolling in the areas of mining rehabilitation will reduce the existing high fire risk in those areas, in particular those with dense understorey, and make future fire management much easier. In all areas thinned, the use of the notching technique to cull trees which leaves them standing, can increase the fire risk because if these trees burn they could allow a fire to cross fire breaks by shedding bark and burning limbs. To reduce this risk the project will use the cut-stump thinning technique which culls the trees by felling them, near burn boundaries as well as near public access areas. Thinning and prescribed burning will reduce the risk of wildfire by reducing the amount of fuel available for burning. It will also help move the forest towards a more mature structure that has a larger distance between understorey and overstorey canopies and so make prescribed burning easier to manage.
Answer	Fire management is an important part of catchment management, and is part of the Wungong project. Fire management will be undertaken in accordance with CALM’s fire management policies and procedures.

2.4 Reserves

Issue	Why are there so few formal reserves in the Wungong Catchment?
Submission quotes	“[project document] failure to explain the low % of the catchment in formal reserves (reserves mainly in the better preserved Canning and Serpentine catchments near-by)”
Summary of issue	• There appears to be a low fraction of the Wungong Catchment in formal reserves compared to nearby catchments.
Response	While the Wungong Catchment does have part of a proposed National Park in its south-east corner, the issue about the creation of formal reserves is dealt with by the Conservation Commission of Western Australia (WA) as part of its Forest Management Plan. About 38% of the catchment will not be thinned including proposed National Parks, stream buffers, and fauna habitat zones.
Answer	This is not directly a project issue, as it is addressed in the Forest Management Plan and managed by the Conservation Commission of WA.

2.5 Health – general

Issue	How will thinning impact on the general health of the community by way of mosquito borne disease?
Submission quotes	“Mosquito borne disease: There is a growing body of evidence suggesting that biodiversity is protective against mosquito borne disease: in theory, a healthy biodiverse ecosystem will preclude the relatively more r-selected vector mosquitoes by competition and predation. One would predict therefore that changing the forest structure to a more mature state would reduce the number of potential vectors of Ross River virus in the catchment. This is significant not only because it might decrease the infection risk for recreational users, but also because there are wider implications with the possibility of applying the findings from Wungong in many other areas.” “It should be clear from the above that I see no major public health risks associated with the project (and there may even be an improvement in the medium to long term).”
Summary of issue	• Healthy ecosystems can improve the health of the community by reducing the risk of mosquito borne disease, and as thinning helps move forest to a more mature structure it may reduce the number of potential vectors of Ross River virus. • No major public health risks with project.
Response	The health of the community is paramount to the Water Corporation, in particular as it relates to the provision of safe drinking water. If there is some additional indirect benefit to the general community health from catchment management this would be welcome.
Answer	The project is expected to have neutral or positive impact on community health related to mosquito borne disease.

2.6 Water quality – health

Issue	How will thinning impact on drinking water quality?
Submission quotes	“[supports project if] physical activities conducted within the catchment to introduce and maintain the thinning program will have no affect upon source water quality” Department of Health “Any activity in catchment areas is likely to be detrimental to water purity” “Pathogen runoff: With increased flow, there is always potential to decrease the transit time of faecal pathogens in the ecosytem, so that more animal pathogens can enter the reservoir in a viable state. For pathogens that have resting stages, are resistant to chorine, and infect humans, this can be a problem (eg Cryptosporidium). The main risk lies in heavy rainfall events, but the document indirectly covers this contingency in discussing the turbidity that usually accompanies such events. The fact the dam can be taken off line should provide adequate protection of the public health.” “... the project provides an opportunity for a number of matters to be investigated in relation to water quality protection and salinity .. the Wungong Catchment is a public drinking water source area. The relative change in water quality parameters pre and post thinning will provide data for use in advising policy and guidelines for clearing controls around reservoirs and their feeder streams.” Department of Environment “All the Water Source Protection Plans that I have seen stress the importance of maintaining natural vegetation in catchment areas, and give sound reasons to support this”
Summary of issue	• Health Department supports the project if physical activities in the catchment are not detrimental to water purity. • Increasing streamflow can increase pathogen runoff, in particular during heavy rainfall events – but with the contingency of being able to take the dam off line this should provide adequate protection of the public health. • As an experiment there are opportunities for improving understanding related to clearing controls around water reservoirs and streams. • Natural vegetation should be retained in catchments to protect water quality.
Response	As the focus on the thinning within the catchment is non-commercial, with the culled trees mainly being left within the catchment, there is little need for large vehicles and off road access that may disturb the catchment. In parts of the older mining rehabilitation, there is expected to be some commercial timber which would require log trucks to remove the material from the catchment. Water quality risks can be reduced by operating large vehicles under dry soil conditions which will be encouraged. The thinning contractors will be asked to use portable toilets when operating within the Reservoir Protection Zone (2 km buffer around reservoir), mix any chemicals outside the catchment and conduct vehicle maintenance (such as oil changes) outside the catchment. Forestry activities, the main physical activity for the project, can be done at

	minimum water quality risk when best practice is followed. Previous research indicates that roads can be the major contributor to stream sediment and turbidity. There will be limited new road construction for this project. There is little direct surface runoff, with most water moving to streams as sub-surface flow. Bauxite pits are self contained and also stream buffers will reduce turbidity. Stream buffers will be implemented in accordance with the Forest Management Plan. These currently include a buffer that is 30 m on either side of first order streams, in the highest parts of the catchment, and up to 200 m for fifth order streams closer to the reservoir. The project will also have a 100 m buffer around the Wungong Reservoir. These buffers help protect water quality and ecology values. As rain water mainly moves to the stream as sub-surface flow, stream buffers allow soil to act a natural filter. The Forest Management Plan, facilitated by CALM, has commitments during the current plan to investigate the effectiveness of stream buffers for protecting ecological, water quality and quantity values. The Water Corporation will participate in this investigation with other organisations. Water quality monitoring in the Wungong Catchment will be extended from the Water Corporation's normal catchment raw water monitoring. This will including installing and using pump-samplers to initially take daily measurements of water near treatment operations. These samples are analysed every few weeks in a laboratory for a range of parameters. As the project continues, the frequency of measurement will be changed if required depending how quickly parameters change or remain constant. If there are incidents within the catchment, such as chemical spills, they will be reported to the Water Corporation for immediate action.
Answer	The project is expected to have a low risk on water quality health parameters. Even so, a monitoring program and incident reporting will be used to determine whether there is an impact and if immediate corrective action or modifications to management measures are required.

2.7 Water quality – salinity

Issue	How will thinning impact on stream salinity?
Submission quotes	“[supports project if] the salinity of Wungong Dam does not increase as a result of the raised catchment water table” Department of Health “This [dryland salinity problem in Blackwood catchment] also resulted an increase of saline water entering our water ways and water storage.” “Salinity of the water in the Wungong catchment is low ... but it may be a problem in other catchments ... any results from this trial cannot be applied or used to justify similar tree killing in other catchments” “Salinity is not thought to be a problem in the Wungong catchment. This may be true for human use of water, but the brief rise in salinity that has followed logging and burning in the karri forest even where stream buffers were provided may be disastrous for aquatic ecosystems.” “project will lead to salination of the dam’s drinking water in the long term” “Salinity is said not to be a problem in the Wungong catchment (para 6.2.1, p. 70). This may be true for human use of water but not for aquatic ecosystems. Research in the karri forest has shown that there is a brief rise in salinity following logging and burning even where stream buffers are provided and that this is lethal for some aquatic fauna. We may expect similar impacts in the jarrah forest. Even if salinity is not a problem in the Wungong catchment, it may be a problem in other catchments, so results from any trial in the Wungong catchment cannot necessarily be applied elsewhere.” “Is forest thinning anticipated to the (historic) 900-1100 mm annual rainfall zone? This has, in the past, been treated as an area of salinity risk. How do the changing isohyets (if permanent) over the past 7 years affect this logic or the risk?” CSIRO Land and Water “It is therefore difficult to understand ... why the proposal to clear land has been put forward and its implementation given such a high priority by the present Western Australian government. The historical data indicates that the result of further clearance will be the degradation of more land, an increase in salinity levels of rivers/streams with the consequent downstream impact on agriculture and the populations of towns such as Armadale and Byford and the removal of valuable topsoil by erosion.” “In the very strongest terms I wish to register my amazement that you could embarrass yourself by making such an ignorant statement. For 50 years we’ve been trying to correct the early settlers terrible mistake of clearing the land, especially catchments and you say you give us cheap water that way? Why is Wellington Dam often so salty that it is hardly fit for irrigation? Why was Barry Oldfield, President of ‘The Men of the Trees,’ awarded the Order of Australia Medal? Why have countless millions of dollars been spent on tree planting and riparian conservation measures? NOT TO GIVE US MORE SALT WATER. Most school children know these things. Where have you been?” “I wish to express my very strong opposition to the above proposal. I have read about and seen the long term devastation to farming land and to water quality that has come from the clearing of land generally and of catchments

	specifically.”
Summary of issue	• Thinning will cause the Wungong Dam to go salty in the longer term. • Dryland salinity is a problem in some catchments and results from this project can not be transferred to other catchments. • Will a drying climate mean the salinity risk of catchments changes? • Clearing vegetation from catchments causes stream salinity and erosion.
Response	The Wungong project has been developed over the last three years in consultation with a range of stakeholders and experts, building upon several decades of forest and hydrological research within the South West of WA. Past research has demonstrated that extra streamflow can be provided by catchment thinning in the high rainfall area, without impacting upon water quality in the streams or the dam – in particular without any significant change to stream salinity. There is research that has demonstrated there can be salinity problems if land is cleared in the lower rainfall areas of catchments. But in the higher rainfall areas the salt from rainfall has been better flushed through the soil profile, and research has demonstrated that land-uses such as thinning are not expected cause a salinity problem. More information can be found from the Department of Environment’s (DoE) report SLUI31 “Water Yield Response to Land-use Change in South-West Western Australia” (Bari and Ruprecht, 2003) available on the DoE web-site www.environment.wa.gov.au. One of the main reasons the Wungong Catchment was chosen as an experimental site, was it was representative of the high rainfall areas of other Metropolitan catchments in terms of its hydrology and salinity risk. This means that the results from the Wungong Catchment project can be used to understand the impact of catchment thinning in the high rainfall areas of other Metropolitan catchments with appropriate hydrological advice. As our climate changes, such as the reduction in rainfall after 1975 and again after 1996, our understanding and management of catchments needs to be updated. The intermediate rainfall zone (900–1100 mm annual rainfall) based on the climate to 1980 is the current benchmark for salinity risk assessment. The salt stores that make clearing vegetation in the intermediate rainfall zone risky for salinity, were built up over hundreds of years. This lag between changes in rainfall patterns and salinity risk means longer term rainfall patterns provide a better guide to salinity risk than the current drier rainfall patterns. A submission has made reference to research about logging and burning in the karri forest. As this involved some clear felling, it is not applicable to the Wungong project. The time it takes for a new equilibrium to form based on a new climate is not known, but is likely to be several decades and beyond 12 years of the Wungong project. That said, it is a question hydrologists can answer with some level of certainty using computer models and the Water Corporation will be seeking the appropriate expertise to find an answer during the Wungong project.
Answer	The project is expected to have a low risk of increasing stream salinity in view of the results from previous catchment thinning in other high rainfall areas.

2.8 Chemicals in catchments

Issue	Is Roundup® safe to use in drinking water catchments for catchment thinning?
Submission quotes	“[supports project if] only chemicals approved by the Department of Health or in accordance with Public Sector Circular 88 - 'Use of herbicides on water catchment areas', are applied within the catchment” Department of Health “Roundup® application: The health risks have been dealt with well. I do not see any issues here provided that good protocols are in place for the immediate reporting of spills.” “There is increasing concern about the use of this [Roundup] herbicide, especially in water catchment areas, even if it is injected rather than sprayed” “Thirty or forty years ago, DDT would have been found in every garden shed ... DDT is no longer considered safe ... no chemical control [should] be used in our catchment areas” “Your report gives a very detailed account of the options available for thinning, and while we don’t necessarily agree with the notion of thinning, it would appear that thinning by stem injection is the more viable option in that it will cause less disturbance to the under story. However we struggle to accept the notion of spraying with herbicides within the catchment area.” “The proposed herbicide is Roundup® (para 6.2.2, p. 71), whose active ingredient is glyphosate. There is increasing concern about the use of this herbicide, especially in a water catchment, even if it is injected rather than sprayed.” “The ... objects strongly to the use of all herbicides and other chemicals in a potable water supply catchment. Thus we do not support the notion of the 12 year 'trials' or 'research' which depends on very extensive use of chemical herbicides to kill trees and then to follow up in killing coppice regrowth, weeds, and new undergrowth.” “We shouldn’t be using herbicides in a water catchment area because of the risk of it going into the catchment with the run off. We do not believe that the Water Corp can unequivocally claim that this is safe. We are not convinced that this would not pose risks to the health of aquatic ecosystems. Especially given Denmark’s recent decision to ban certain uses of Roundup® because of it making its way into waterways, we have concerns about the safety of its use within a catchment with regards to human consumption. We do not believe there has been enough independent scientific verification of what are essentially Monsanto’s claims that it is safe.”
Summary of issue	• Strong objection to using herbicides, in particular in catchments. • Use of herbicides appears to have less impact on understorey. • Concern not enough is know about Roundup® and when more is know it will not be considered safe, in the same way DDT was banned. • Protocols are required in case of a chemical spill. • Department of Health supports the project if approved chemicals are used and chemicals are used in accordance with the Public Sector

	Circular number 88.
Response	Use of chemicals, in particular in drinking water catchments, is an important decision, because if chemicals are used incorrectly they can be dangerous to the environment and public health. The primacy of drinking water is critical to the Water Corporation and it makes decision by putting water quality first. A water quality risk assessment, available in the project document, concluded that using herbicides has a low management priority, and its risk was lower than other thinning methods, such as ring barking, manual coppice control and pulling tree and stump out. The herbicide to be used for the thinning in both the notching and cut-stump technique is Roundup® (active ingredient glyphosate), which is on the list of chemicals approved by the Department of Health for use in drinking water catchments. From the herbicides on that list, Roundup® is the least harmful. It will be used in low volumes and handled according to existing best-practice guidelines. There are public concerns about use of herbicides, including Roundup®, but that doesn't mean they are all unsafe. The Danish Environmental Protection Agency did propose that Roundup® was restricted for certain uses in 2003, but after more consideration it stated on 14 December 2004 there was no need for the autumn restriction. The Water Corporation will continue to monitor the outcomes of scientific investigations into the safety of herbicides. Without using Roundup® the thinning would not be effective and more frequency repeat work would be required. This greater disturbance would have a greater risk to water quality than if Roundup® was used in the first place. With a decision to conduct a thinning operation, using a herbicide like Roundup® is the safest solution. Roundup® has been used safely for many years, and water quality monitoring will be used to check the public is safe. A version of Roundup® will be used that further reduces the risk to the aquatic environment in the unlikely event of an accidental small spill. There are also procedures to minimise the risk of accidental spillage within the catchment. These procedures provide for the safe transport, handling, preparation, application and accounting of herbicides. While accidental spillage of chemicals will be responded to, there are natural processes that help reduce the risk to the environment and water quality. A wide range of physical, chemical and biological processes contribute to removal of contaminants from water flowing through soils. These processes include sedimentation, plant uptake, inactivation, chemical adsorption, and volatilization. Should any unwanted chemicals enter the catchment, removal of contaminants and chemicals may be accomplished naturally through storage in the subsurface and vegetation, or through losses to the atmosphere.
Answer	Roundup® is approved for use in drinking water catchments by the Department of Health and will be used safely with appropriate best practice.

2.9 Water quality – turbidity and soil – erosion/acid sulphate soils

Issue	How will thinning impact soil erosion and stream turbidity?
Submission quotes	“Increased soil erosion is likely to be a problem” “Clearing or thinning or any other activity that reduces plant cover of the soil also gives rise to surface erosion and siltation of the dam” “The clearing of forest canopy also allows pelting rain to pulverise the surface soil causing loss of soil structure, destruction of vital soil fauna habitat, and the reduction of a living earth to an impoverished mineral dust.” “Clearing is likely to increase water salinity and sediment run-off in creating ‘muddy’ water. This fact is well recognised and catchment clearing is specifically highlighted as inappropriate, perhaps even historically naive, in CALM information such as the Hills Discover Centre at Mundaring.” “When Mundaring Dam was first built the hillsides leading to the Dam were cleared. Results were recorded as disastrous with silting from erosion and decline in water quality.” “What about the increase in turbidity? In the Hills we are all too familiar with the Water Corporations response to disturbed catchments leading to a deteriorated water quality – build a chemical treatment plant. End of pipeline solutions are not good enough – we have to be addressing and reducing the causes of problems, not just band-aiding the symptoms.” “We were not convinced by the WCMPD that the proposed ‘thinning’ will not cause soil erosion within the catchment. As the dead trees’ roots rot their role and capacity to hold soil in place will diminish.” “We were similarly worried about the possibility of causing acid sulphate soils from disturbance from proposed logging and general soil erosion caused by the gradual decrease of live deep roots holding soil in place.”
Summary of issue	• Removing trees exposes soil to damage and being washed away. • Clearing trees is likely to cause erosion and turbidity. • Dead trees can not hold soil and there is a risk of acid sulphate soil.
Response	Following on from the responses to issues in Sections 2.6 to 2.8, the issue of erosion is also important to the Water Corporation because of the primacy of drinking water. Water quality is about catchment to tap management, not just about treatment solutions. The project has a focus on non-commercial thinning that will initially change the spacing between trees from 3-4 m to 5-6 m, i.e. retrain about 300-400 trees per hectare. Wildfire is a much greater threat as shown by the massive erosion in the Perth Hill’s fire area (from intense January 2005 wildfire) The on-ground activities will mainly be non-commercial thinning of selected trees involving a small truck or four-wheel drive and a small gang of workers that walk through the forest culling selected trees. This is not a large scale clearing, nor on the whole, involves heavy vehicles that can disturb the soil if used inappropriately. That said, some heavy vehicles will probably be used for the older mining rehabilitation which could be felled commercially within internally draining bauxite pits. The change in forest cover is not extreme and

	while more soil will be exposed to rainfall, the hydrological process in the Wungong Catchment involves infiltration and movement of water through the ground with little direct runoff. Acid sulphate soil problems occur when ground containing iron sulphates are drained and oxygen can react with them to form sulphuric acid. Thinning will tend to increase soil moisture, hence this is not expected to be a problem, even if these soils were present which is unlikely. Retained trees grow faster after thinning and continue to hold the soil. So while the dead trees will eventually rot, there will be plenty of other vegetation including the understorey, to maintain the soil integrity.
Answer	The project is expected to have a low risk of generating soil erosion and stream turbidity given the management strategies proposed, and monitoring will be used to determine the impact of the project on stream turbidity and whether corrective action is required to manage the impacts.

2.10 Water quantity – rainfall change

Issue	Will thinning reduce rainfall?
Submission quotes	“Bill Mollison entitled Permaculture – A Designer’s Manual ... if it were accurate when it is possible that forest thinning may result in a net reduction in precipitation, which could also have impacts on environments in the ‘rain shadow’ that may result from a thinned forest” “Minister states that forests do not attract rainfall. What scientific research has been done to prove this? It is general knowledge in the wheatbelt that rain falls more on the uncleared areas than it does on the cleared areas. Research in Canada based on trial plots of the native juniper trees and the – to them – exotic eucalyptus, indicates that the Juniper has better capabilities of attracting rainfall than the eucalyptus” “local climate and weather patterns can be disturbed by clearing large areas, which may have the effect of further reducing rainfall in the catchment” “I would like to see the monies that have been provided used for research on rainfall. The culling of trees could increase the initial run-off but would reduce rainfall! An example of trees affecting rainfall is given in a book by Richard St. Barb Baker, citing a city in California that had Eucalyptus on one side and Cypress on the other. It was found that precipitation in the Eucalyptus forest was thirteen inches per year, and precipitation in the Cypress was thirty inches per year. The Superintendent of Parks decided to fell both of these woods as an experiment and replace the Eucalyptus with the Cypress plantation and the old Cypress plantation with Eucalyptus. In three years the figures for precipitation were reversed. The old Eucalyptus side (now Cypress) had thirty inches! There are other examples; for instance – rain falling on the bushland side of the rabbit-proof fence in WA; also, it is common knowledge among the Western Australian farming community of rain falling on the bushland reserve but not on the cultivated areas.” “Cleared vegetation, to the extend of progression towards desert, affects rainfall in that it is reduced because of air moisture being vaporised by air, super heated by radiated heat coming from hot ground.” “The feasibility of the Wungong Dam thinning seems like a good idea, better than an expensive desalination unit that will put extra salt back into an already shaky coastal system. However, as everybody in Australia knows, trees produce our water anyway, so it would be a good idea for all forestry industries and Governments to have a policy of replacing one tree with three. Australian natives take a long time to establish. Good policy would be, ‘One for now one for later and one for luck, in case one dies’. Please do the right thing by our children. Thankyou for your time.” “Clearing 60% of the trees in the catchment areas of the dams supply water to Perth. When I saw and listened to this news article it was as through I was in a surreal time warp. Primary school students can tell you that trees produce oxygen and bring precipitation. Why would the Water Corp or the Government be planning to chop down 60% of the trees in our water catchment areas? This is just too unbelievable. Some years ago a similar and equally uneducated approach was used in Malaysia and guess what? Rainfall

	dropped.” “Basic high school biology teaches that trees and forests <i>humidify</i> the atmosphere, and drought actually follows on from loss of forest cover. In fact the gradual diminution of rainfall in Western Australia maps <i>exactly</i> the loss of forest cover in this state since colonisation.” “The Greenhouse Effect is an alarming reality and it is necessary that the carbon dioxide in the atmosphere be absorbed, hence there is urgent need to <i>increase</i> the planting of trees and to increase our forest cover, not for more trees to be lost if we are to be responsible global citizens, and if in fact we are to invest in our own survival.”
Summary of issue	• Clearing trees reduces rainfall. • Trees produce water. • Overseas research demonstrates rainfall is effected by vegetation.
Response	Forests are an important part of the global water cycle, but do not themselves create or attract water. Water evaporates from oceans, forms clouds, which in turn precipitates as rainfall in our forested catchments. The water use by forests within our catchments is the largest part of the water balance, so it is important the forests are managed appropriately. The water that ends up in the streams is only around 5% of the amount that falls as rain (as an annual average for Perth’s Metropolitan catchments). In huge moist catchments like the Amazon Basin it is likely that some rainfall within the catchment has been sourced from transpiration by forest within the catchment. California is a very different environment, with fog drip a major component of precipitation and this is not the case in WA. The catchments in the Darling Range near Perth are very different to the Amazon and California. Changes in rainfall in the south-west of WA are dominated by changes in large scale atmospheric and ocean circulation, rather than land-use changes. There was a significant step decrease in rainfall around 1975 across the south-west of WA which did not correspond to any similar step change in land-use at that time, such as agricultural clearing. There is research by the Macquarie University to show that large scale clearing of about 16 million hectares in the agricultural region of south west WA has contributed to the reduction in rainfall due to the difference in surface friction and light reflection between forested and cleared land. Even so, this is still considered by climate researchers to be a secondary influence on rainfall decreases (see www.ioci.org.au for more information). Also, there is no research suggesting that removing selected trees in a non-commercial thinning operation, which leaves the forest canopy intact as far as wind friction is concerned, will impact local rainfall. The Wungong project is about thinning selected parts of a single catchment and not clearing, and so is not expected to reduce rainfall. The drying climate is of concern and as a community we need to adapt to the observed and projected changes. The enhanced greenhouse effect and natural variability are seen as the causes of the reduction in rainfall around 1975. As the Wungong project impacts vegetation, which has a major role in regulating the carbon dioxide in the atmosphere, it is import to understand whether or not this impact will increase greenhouse gases. Initial calculations have shown the Wungong project is greenhouse neutral, with the carbon dioxide released

	from the thinned trees being balanced by the carbon stored on the retained trees which grow faster after the thinning. The extra water recovery from the project will help mitigate the impact of the drying climate on the stream ecology as well as the community's water supplies. Rainfall will be measured as part of the project and some rainfall stations that had been closed will be reopened. These data together with other data already being collected, can help monitor any potential changes in rainfall, whether from land-use or climate change sources.
Answer	The project is not expected to have any measurable impact on rainfall.

2.11 Water quantity – streamflow

Issue	Will thinning increase streamflow and what other factors influence streamflow?
Submission quotes	“Old Mountain Ash forests [in Victoria] ... yield almost twice the water of young regrowth forest” “We are not convinced that the expected increase in streamflows and thus yield from thinning are realistic as there is no analysis or presentation of scenarios for differing rainfall levels in future years.” “To what degree can declining yields be attributed to (a) climate change, (b) changes in forest structure, (c) bauxite mining and/or (d) change in burning frequency?” “To what degree are water yield models conditioned not only for a potential change in rainfall but for other climatic factors as well (temperature, vapour pressure, rainfall intensity, etc)? These may also be changing.” CSIRO Land and Water “One wonders if this is a hairbrained scheme, untested elsewhere in Australia, or of proven value in comparable landscapes. Or is it just another PR exercise?” "Even cursory research indicates that in fact thinning of water catchment areas has a <i>drying</i> effect on soil and upon the atmosphere over time. Forest thinning will in fact have the <i>opposite</i> effect to the stated aim of this proposal ie: increasing water supply and the amount of water in our dams." “Whilst it may be true that following partial clearing in a catchment there are increases in water run off, but we believe that this is a shortsighted and anthropocentric way of viewing our environment. We believe given increasingly alarming statistics regarding the effects of cumulative damage to our environment and ecosystems that the Water Corporation should reconsider this proposal.”
Summary of issue	• Experience from Victoria shows mature forest yields almost twice as much streamflow as regrowth forest. • Uncertainty from some and more certainty from others that the thinning will achieve projected streamflow increases, in particular with a drying climate. • Question about different impacts for different land-uses on streamflow and all climate parameters.
Response	The streamflow increase projections in the Wungong project are based upon several decades of forest and hydrological research within the South West of WA. Past research has demonstrated that extra annual streamflow can be provided at approximately one gegalitre per thousand hectares of regrowth forest thinned in the high rainfall zone. More information can be found from the DoE's report SLUI31 “Water Yield Response to Land-use Change in South-West Western Australia” (Bari and Ruprecht, 2003) available on the DoE web-site www.environment.wa.gov.au. The project has considered two climate scenarios. The projected increase in annual streamflow of 25%, is 4 or 6 GL depending on whether the current 1997–2003 climate continues or if the wetter 1975–1996 climate returns.

	Whatever the rainfall scenario, it is expected that there will be a relative increase in streamflow from non-commercial thinning. Streamflow is currently measured at sub-catchments which contain several activities or land-uses. Each land-use will have some impact on streamflow, and as streamflow is integrated at the gauging station it is not possible, even with local groundwater table measurements, to determine with absolute certainty the relative contribution of all land-uses by physical measurement alone. This is not necessarily a problem as measurements will describe how a particular management regime is impacting on streamflow. Using computer models can help provide attribution of changes to streamflow, in particular if combined with detailed process field experimentation on an individual tree or small plot scale. Hydrological computer models have been able to re-create streamflows with good correlations for a range of changes in rainfall, leaf area and ground/soil profile. For example, these models can reproduce a large decrease in annual streamflow with a modest decrease in rainfall such as was observed in 1975. Other land-use changes, such as past changes in forest structure, current forestry and fire management, infestation from dieback and bauxite mining, might have predisposed the catchments to respond a particular way, but the model only needed the rainfall changes to get the correct answer in that case. Models can always be improved and current models that investigate annual streamflow changes typically use daily rainfall and not other atmospheric parameters such as temperature and vapour pressure. As the climate is expected to continue changing it is important to understand the impact of changes due to all climate parameters, in particular those that impact on vegetation which controls the largest part of the catchment water balance. If possible this hydrological work will be integrated into the project's research program. More work will be done within and in conjunction with the Wungong project to better understand the impact of various land-uses and climate parameters on catchment behaviour. Specially work will continue on understanding the impact of • Bauxite mining and rehabilitation: while mining and rehabilitation has provided a net export of water from the Wungong catchment so far, if current trends continue this situation may reverse without intervention. • Fire management, such as the intense wildfire in Perth hills in mid-January 2005, by reopening two gauging stations (one catchment burnt in the fire, and the other catchment not burnt) and if possible conducting research on more frequent mild prescribed burning. • Forest structure: which is the Wungong project itself – looking at whether non-commercial thinning at a catchment scale can reproduce the streamflow increases demonstrated in 60–100 ha sub-catchments. Streamflow will be monitored within treated areas and within control areas that are not treated, to understanding the impact of thinning. This includes reopening gauging stations, and creating new temporary ones within some treatment areas.
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Answer	The project will have a measurable and useful increase in streamflow for the environment and water resources, and other factors that impact streamflow will be investigated during the project.
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2.12 Water quantity – environmental requirement

Issue	How have environmental water provisions been considered?
Submission quotes	“Under CoAG water reform, Environmental Water Provisions may have to be set for streams below dams in the Darling Range. To what degree has this requirement been factored into the cost estimates for new water yield, or the consideration of thinning treatments?” CSIRO Land and Water
Summary of issue	Environmental Water Provisions are required from dams such the Wungong, and how will this impact the Wungong project or its costs?
Response	In the context of a drying climate the Wungong project is about restoring water yields back towards what they were, or at least maintaining them where they are. The prescriptions developed for thinning aimed for a moderate restoration of streamflow to balance the risk to other values while helping improve the forest, that is, it did not aim to purely maximise the streamflow from the catchment. Environmental Water Provisions below the dam are not directly part of this project.
Answer	This project will make more water available to the environment above the dam, and provide more water to share between potential competing water uses – but has not directly considered Environmental Water Provisions below the dam as they are not directly part of this project.

2.13 Water quantity – local water cycle

Issue	How will catchment thinning impact the local water cycle?
Submission quotes	“When does the canopy transpiration take place” “how much more evaporation from the shadeless ground will occur after the trees have been thinned?” “Thinning the forest canopy will give rise to increased diurnal flux. The seasonal ambient temperature of the soil is affected, hotter in summer, colder on clear winter nights. The humidity of the under storey and feeder root zone is also subjected to a greater range. This in turn affects the natural occurrence and flow of subsurface moisture, which also leads to stress in the remnant vegetation. Natural springs dry up, remnant vegetation become stressed.” “Whether vegetation is thinned out or not, the rate of soil soakage would be much the same and if anything higher where thinning occurs, because, although the rate of runoff may be slowed by vegetation allowing more time for water to soak away, there is also to be considered the factor that thicker vegetation and leaf litter on the ground provides roofing and so allows faster runoff and slower leakage.”
Summary of issue	• What is the timing and amount of vegetation transpiration and evaporation? • Thinning will impact the heat and water balance from forest to underground water flow to reduce groundwater flow. • Infiltration will not be impacted by thinning and leaf litter improves runoff.
Response	Trees use both shallow water and groundwater tables. Most roots are in the top 25–30 cm of soil and this is where most of the water/nutrients are extracted. The deeper groundwater allows the tree to survive during the summer months when the surface layers are often below wilting point. There are preferred pathways (usually old root channels and fractures) that allow water to pass slowly from the surface layers to the groundwater. Evaporation from the leaves and litter probably occurs all the time, driven by temperature, relative humidity and wind speed. Transpiration is an active process that produces photosynthetic products and therefore requires sunlight. Tree and understorey vegetation water usage, and hence transpiration, changes throughout the day and year. It also varies from species to species. In general trees use more water during the day and water usage throughout a year depends on water and energy availability. While we don’t understand the complete water balance for all sites (and therefore can not fully compartmentalise exactly how much is used or lost by each of several hydrologic processes) nevertheless, by thinning it has been shown repeatedly that the stream flow is increased, often substantially. This means that there is also more water going into storage in the soil profile and that more is travelling down preferred pathways to the groundwater table. There is some detailed work by CSIRO from the Collie Catchment that measured water tables and soil moisture storages. Thinning will open the forest canopy and may increase the temperature of the

	soil during summer for several years until the canopy closes again as retained trees grow. The main factors controlling the infiltration of rain water into the ground is the litter on the surface of the ground and the soil hydraulic conductivity. More ground leaf-litter will intercept rainfall to allow it to evaporate and lower soil conductivity will also reduce infiltration. Thinning will increase the amount of subsurface flow as the overstorey transpiration reduces, which in turn will increase streamflow as water moves through the subsurface. At a sub-catchment scale, past research has demonstrated there will be extra streamflow from thinning, but there is less understanding of the movement of water at individual tree or small plot scale. This is a potential area for further research.
Answer	Thinning will increase local soil moisture and groundwater tables, and hence streamflows. During the project, collaborative and other research will be conducted to improve the understanding of the movement of water in soil and vegetation at a plot scale.

2.14 Water quantity – water table

Issue	How do trees change water tables?
Submission quotes	“At some sites the saline water table was rising at an annual average of 500 mm, resulting in the death of native bush remnants as well as tree plantation.” “At some sites which were close to recent tree plantations, the water table had dropped”
Summary of issue	• Tree plantations have helped reduced a saline water table.
Response	Vegetation can have a large impact on the local water cycle including groundwater table levels (see Section 2.13). As part of salinity management tree replanting can be a useful option. Past research has demonstrated there will not be a problem with stream salinity due to catchment thinning. The water table will increase in the lower parts of the catchment after thinning, but as the catchment is in the high rainfall zone there is a low salt store and this will not cause a salinity problem. For more information see Section 2.7.
Answer	Trees draw water from the soil and can change water tables, which illustrates their impact on the catchment water balance. During the project water tables will be monitored at some research sites to understand the impact of thinning and climate on water tables.

2.15 Vegetation – habitat trees

Issue	How will retention of habitat trees be managed in the project?
Submission quotes	“Loss of any significant or primary habitat trees for cockatoos especially Marri and Jarrah.” “Loss of secondary habitat trees i.e. food trees especially Marri and Jarrah. These are often small trees, but could be flagged before thinning occurs.” “Fragmentation of some of the creek line and denser vegetation.” “no definition is given as to what criteria are to be used and who determines as to what a habitat tree is” “Retention of 'habitat trees' is based on visual assessment by foresters according to criteria set out in 'Silvicultural Practice in the Jarrah Forest' (CALM, 2004). Visual assessment by foresters is not a reliable way of identifying good habitat trees, and the number to be left (five per hectare) is unlikely to be adequate for all the hollow-dependent species in the jarrah forest.” “Retention of ‘habitat trees’ is based on visual assessment by foresters according to criteria set out in “Silvicultural Practice in the Jarrah Forest” (CALM, 2004) (para 5.4.1, p. 46). Visual assessment by foresters is not a reliable way of identifying good habitat trees, and the number to be left (five per hectare) is unlikely to be adequate for all 42 hollow-using and 17 hollow-dependent species in the forest (para 6.1.2.3, p. 69), in particular species like cockatoos and possums that require large hollows. The necessity to provide nesting boxes (para 6.1.3, p. 70) is an admission that forest management is not ecologically sustainable.” “Who decided that to retain only 5 habitat trees per hectare was sustainable for fauna protection? ... would like to see scientific evidence that this is an adequate number, especially given that this is not a logging proposal, after which the forest will be left to regenerate for a number of years, but is intended to be repeated regularly.”
Summary of issue	• Uncertainty about how habitat trees are determined, and who decided that 5 per hectare was sustainable for fauna protection. • Current visual assessment by foresters is not considered a reliable way for determining which trees should be habitat trees.
Response	Habitat trees are very important for a range of different sized fauna. The Wungong project is being conducted under the Forest Management Plan 2004–2013, which sets the minimum number of habitat trees to be left. The plan also makes provision for Fauna Habitat Zones which are larger areas of the forest that will not be disturbed by thinning. Within 38% of the catchment there will not be thinning and this area will potentially contain more than the minimum number of habitat trees per hectare. Thinning is predicted to improve the forest and help move smaller diameter trees to a size that makes them useful as habitat trees. This is a longer term improvement. While the EPA have advised that the number of habitat trees per hectare designated in the Forest Management Plan is environmentally acceptable, nesting boxes will be used where they can add some extra value. Tree marking for habitat trees, trees to be culled in the thinning and not culled

	is a critical part of the project and will be undertaken by experienced foresters – who are best suited for this task. There is other expertise about habitat trees in the Wungong Catchment at the Museum of WA, which includes data about the location of some existing nesting trees. The project will encourage the sharing of this information and experience on habitat tree identification in a way that does not compromise the locations of nesting sites. Further training will be provided to the tree markers if required.
Answer	Habitat tree retention will be managed through the implementation of the Forest Management Plan's silvicultural guidelines and its system of fauna habitat zones.

2.16 Vegetation – native regrowth

Issue	Should thinning native regrowth forest be part of the project?
Submission quotes	“The proposal is for permanent partial clearing of the catchment. This is not ecologically sustainable.” “It is not acceptable to kill trees in an attempt to get more water” “empirical evidence that forest disturbance in water catchments is unwise” “Thus the proposal is for repeated disturbances using contentious chemicals. This is not environmentally acceptable or ecologically sustainable.” “The proposal is for permanent partial clearing of the catchment. We have already permanently lost half the forests that grew here prior to European occupation. We cannot afford to deplete any of the remainder by permanent partial clearing.” “The expression 'locked-up' (Executive summary, sentence on top of page iv) should be clarified or explained in terms of forest structure, timeframes and the capacity for jarrah forests to 'self-thin'. A reference from the scientific literature should also be provided to support this sentence.” EPA Service Unit “Selective removal of trees could be seen as damaging to the environment <u>and</u> as a covert means of achieving logging of old-growth areas which are otherwise protected.” “how a decision will be made as to which trees will be retained and which would be felled. We all live in the Hills and have grown up in a Jarrah forest and refute your claim that Jarrah trees only self thin after a long time. The WCMPD admits that there are jarrah deaths on the densely stocked sites (pg 43) – how can you definitively claim that this is from drought and is not self thinning? We can show you areas of Jarrah forest where some of the same aged trees are dieing and others aren't. It is impossible from just looking at the trees to predict which will die and which won't. This is probably because what favours one tree over another is an incredibly complex, interconnected and symbiotic set of variables that are well beyond what can be seen with the naked eye. Alcoa can still not identify exactly why certain plots of Jarrah regrowth grow better than others – to suggest that the complexity of nature can be identified by someone simply looking at certain trees is worryingly simplistic. What if whoever Water Corp gets to select trees to retain and others to fell, picks the wrong trees? What will this mean for biodiversity if the retained trees start dieing and certain areas end up with no trees or very few.” “What do you define as overcrowded?”
Summary of issue	• The project is for permanent partial clearing of the catchment using chemicals and this is not ecologically sustainable. • The expression ‘locked-up’ used in document needs clarification and reference to literature. • Uncertainty of times scales for jarrah forests to self thin. • Uncertainty about how tree marking to select the cull trees is carried out.

	• Concern that old-growth forest will be logged.
Response	Non-commercial thinning of the native regrowth forest is the most important part of the Wungong project and it is also the part that has attracted the most criticism. There has been criticism through the submissions about the need for the thinning and the activity itself. Some of this criticism is from a misunderstanding that the project is about the permanent partial clearing of the catchments, which is not the case (Section 2.1). Other criticism is because the project will use a herbicide within a drinking water catchment as part of the thinning. The herbicide, which is Roundup®, is approved by the Department of Health for this use and is the safest solution to help the thinning succeed (Section 2.8). Finally, most criticism is because some people do not want any more disturbances in the native forest. While some submission raise concerns about tree marking, which will be done by trained foresters using guidelines under the Forest Management Plan (Section 2.15) and water quality (Sections 2.6 to 2.9), behind this is an emphasis of 'do not touch the native forest'. It may be that in some cases native forest should be left alone, but in the case of the Wungong project there is a need to test whether intervention can help. In the context of a catchment mainly containing a native regrowth forest that does not allow as much run-off as a mature forest and in a drying climate – the need for the project is to help restore streamflow for the benefit of the ecology and water resources, and help move the forest towards a mature structure. Given the importance of this thinning to the project, without it the Wungong project would not proceed. Jarrah is a long lived, tough tree, and nature will make changes to suit the conditions. Some individual jarrah trees may die young, but as a whole the jarrah regrowth forest tends to stagnate (or 'lock-up') and is expected to take centuries to self-thin. If it survived at all it would probably take 300 years to grow from 20 to 50 cm diameter (Stoneman, G.L., Bradshaw, F.J. and Christensen, P. (1989) "Silviculture". In B. Dell, J.J. Havel & N Malajczuk (eds.), <i>The Jarrah Forest - A complex mediterranean ecosystem</i>, pp. 335–355. Kluwer Academic Publishers, Dordrecht.). The regrowth forest in the Wungong Catchment is for the most part overcrowded, in that there are too many trees per hectare, which compete for resources such as light and water. In a drying climate, thinning is expected to help reduce water stress on the forest and prompt growth of individual retained trees to help move the forest to a more mature structure (Section 2.22). There are differences between mining areas rehabilitated to native species and a native regrowth forest. In particular the planted stocking rates of the mining rehabilitation are on average higher than the regeneration in the regrowth forest. In general this means drought deaths are more likely than in a regrowth forest when rainfall is significantly reduced. Drought deaths may be part of self-thinning, but this process will take a long time to move the forest towards a mature structure. With a climate that is drying quickly compared to the life expectancy of a jarrah tree, it may be better to proactively move the forest to a structure that allows it to cope better with less rainfall – rather than let it

	react after being stressed by lack of soil moisture. Thinning of the native regrowth forest will be a key part of the Wungong project. Thinning of forests is a practice that has been conducted for many years. There will be no thinning in old-growth forest. Appropriate water, flora and fauna monitoring based on extensive baseline data for the catchment, will be used to check the impact on the catchment environment.
Answer	Thinning the native regrowth forest is an essential part of the project as this trial will help guide future management decisions for water catchments in a drying climate that primarily contain native regrowth forests. Unthinned controls will be maintained for comparison.

2.17 Vegetation – mining rehabilitation (native species)

Issue	Should thinning native mining rehabilitation be part of the project?
Submission quotes	“... does not support tree killing over the entire area ... submits that long-term thinning trials be continued in this area. The trials should range from doing nothing through to the intensive killing as stated in the proposal” “The soil profile and hydrology in these former bauxite pits have been radically modified and the immature rehabilitation is a poor replica of the original forest. We recommend a very long-term (200 year) trial of different treatments, from doing nothing (to see at what age jarrah self-thins) to intensive tree-killing, without the use of chemicals, to grow jarrah for sawlogs” “The soil profile and hydrology in these former bauxite pits have been radically modified and the immature rehabilitation is a poor replica of the original forest. We recommend a very long-term (200 year) trial of different treatments, from doing nothing (to see when at what age jarrah self-thins) to intensive tree-killing, without the use of chemicals, to grow jarrah for sawlogs. However, modification of Alcoa’s rehabilitation could mean that the State may have to accept liability for future failure, so the legal implications of this proposal must be investigated.”
Summary of issue	- Do not want all the mining rehabilitation killed, and 200-year trials should be conducted with different treatments with the aim of growing sawlogs. - There might be liability issues for modifying Alcoa’s rehabilitation.
Response	Twenty percent of the Wungong Catchment has been mined by Alcoa World Alumina Australia (Alcoa) and all of this has been rehabilitated. The prescription for the rehabilitation changes as better ways are discovered, with a major change in 1988. Before 1988 introduced species were used (eastern states exotics), as there were concerns the locally native species might become infected with dieback (Section 2.18). After 1988 when it was found the native species did not become infected, the prescription changed to use native species. The area mined and rehabilitated is dispersed across the catchment, although there is more native rehabilitation on the eastern half of the catchment. There is currently no active mining in the catchment, but the rehabilitation is current still the responsibility of Alcoa until it is accepted back by the State. The Water Corporation will not arrange thinning of these stands until there is agreement between the Mining and Management Program Liaison Group (MMPLG), CALM and Alcoa. The first area planned for thinning in the Wungong project has been presented to the MMPLG for handback. There is good progress being made on this issue, and CALM have indicated it will not hold up the project with this issue. The treatment prescriptions for thinning in the native rehabilitation is similar to the native forest and it does not involve killing all the trees as suggested by some submissions. The concept of doing further trials in the rehabilitation is something that Alcoa is already doing, and this will help improve the design on the rehabilitation prescription.

	As with the native regrowth forest, the thinning of the native rehabilitation will be an important part of the project. It will help improve the rehabilitated stands by reducing fire risk (Section 2.3), improving stand growth and increasing the runoff (Section 2.11).
Answer	Thinning mining rehabilitation (native species) is an important part of the project, but unthinned controls will be maintained for comparison.

2.18 Vegetation – mining rehabilitation (exotic species) and pine plantations

Issue	Should thinning of the exotic trees species and gradual conversion back to native species be part of the project?
Submission quotes	“supports the reversion of the area back to native forest” “Once cleared and mined, land can never be 'converted back to native forest' with all its biodiversity restored. However, we fully support replanting/reseeding the area with endemic species” “We do not have a problem with commercial harvesting of plantation trees but we do have concerns that commercial felling of jarrah trees is also part of this project.” “Once cleared and farmed, land can never be ‘converted back to native forest’ with all its biodiversity restored. However, we support replanting/reseeding with endemic species and we recommend substitution of areas of already cleared land outside the catchment to replace the former plantations within the catchment.” “we support the harvesting and removal of pine plantations and the timber may as well be used commercially” “... fully supports the removal of all pine plantations and plots (300ha) as well as exotic species planted on exhausted mine sites (1100ha) and dieback rehabilitation sites planted to exotic species (1000ha), with replanting and reseeding with endemic species, providing these operations are subject to the strictest hygiene possible.” “Qualifying statements need to be introduced in sections of the document, which mentions the conversion of the existing pine plantations to native species. This is to inform the reader of the likelihood of this component of the project being implemented (eg. subject to xyz occurring) and the contingencies available.” EPA Service Unit “The project refers to exotic native species planted as part of the mine rehabilitation operations for their dieback resistance values being convert to native species. The species are generally Australian Eucalypts not native to the area, for example, <i>E. robusta</i> and <i>C. maculata</i>. Although local species are preferred in native forest areas, some exotic natives are productive timber species with good resistance to dieback. The ... does not advocate their removal unless they demonstrate aggressive weed properties.”
Summary of issue	• Support for conversion of exotic vegetation to native species • Concern that land once cleared and mined can never become native forest with all its biodiversity restored. • Recommend using already cleared land outside catchment to replace former plantations within catchment. • Exotics are useful timber resources and should not be removed unless they become aggressive weeds.
Response	In the project document the Water Corporation never claimed that the conversion of pine plantations or exotics to native forest would restore “all

	the biodiversity of the original jarrah forest”, merely that local provenance native species would be more desirable environmentally, and one that most support. Following from the discussion on native mining rehabilitation in Section 2.17, the main exotic or introduce species are from the pre-1988 mining rehabilitation (9% of catchment area). There is also a small pine plantation (2% of catchment) that has recently been clear felled by Forest Products Commission (FPC). In all these areas the aim is to have native vegetation with the appropriate structure. This will involve a gradual conversion within the mining rehabilitation and finding FPC some alternative land to replant their pine plantation. The Water Corporation had searched its land holdings, but has not found suitable cleared land. There is general support for this part of the project. While the treatment of the exotic species in the mine rehabilitation is subject to the same constraints as the native species (Section 2.17), this part of the project has a much higher chance of proceeding than the rehabilitation of the pine plantation – given the limitations of finding suitable land.
Answer	As there is general support for thinning and gradual conversion of exotic species to natives, this will be an important part of the project.

2.19 Vegetation – small weeds

Issue	What is being done about control of weeds?
Submission quotes	“concerned that the thinning process, which will allow more sunlight to reach ground level, may cause unwanted weed growth and re-vegetation of the undergrowth thus defeat the purpose of the forest thinning to encourage more run off” “The ... supports weed control in the catchment but only by either mechanical means or benign practices such as steam spraying. We object strongly to the use of chemical herbicides in the catchment as these compounds are estrogen mimics and should not be allowed to enter catchments for potable supply. We are concerned that this practice is already in common use by CALM in water catchments (p71). We are also concerned that Roundup® may already be in use in the Wungong catchment. We submit that steam methods which are available and are used elsewhere should replace all chemical use.”
Summary of issue	• Thinning may cause unwanted weeds and understorey. • Weed control is supported, but only with mechanical means or steam spraying – not with herbicides.
Response	Natural competition within a forest means when the forest canopy is opened other species will try to grow. The soils in the jarrah forest are quite infertile which restricts the growth of most weeds. Some species such as banksia do sometimes regenerate as a ‘wheat-field’ after the canopy is opened and may require controlling. That said, larger specimens of key understorey species (such as balga, banksia, sheoak and snotty-gobble) will be retained as individuals or in groups – contrary to some submissions which suggest they would be removed. In the longer term the retained trees will grow and the canopy will close to suppress weeds and unwanted regeneration (Section 2.22). It is important when controlling the weeds to minimise the disturbance on the catchment to reduce the water quality risk. Mechanical and steam methods are not expected to be as effective as using appropriate herbicides and would require more re-treatment and so increase the risk to the drinking water quality. The methods used will include herbicides that are approved for use in drinking water catchments (Section 2.8).
Answer	Weed control is an important part of catchment management and will be done as part of the project in conjunction with others, such as CALM, who have prime responsibility in this area.

2.20 Vegetation – understorey

Issue	How will thinning impact the forest understorey and small fauna?
Submission quotes	“Following the discussion during the meeting on the likely effects of thinning on the understorey, further information and clarification should be included in the appropriate sections of the document on how the understorey would be improved by this project.” EPA Service Unit “We have grave concerns about the impacts of reducing the canopy cover on the under storey species and smaller trees including re-growth, due to over-exposure to the elements ie more sun and wind leading to increased evaporation and an increased vulnerability to drought stress. Less canopy cover will also expose small mammals to increased predation and reduce habitat.”
Summary of issue	• How will understorey be improved? • Concerns thinning will impact understorey and small trees due to over exposure to sun, wind and increased evaporation • Less canopy cover will reduce habitat and increase predation of small mammals.
Response	The exact extend of the impacts of thinning on the understorey are uncertain, but are not expected to be negative. Monitoring and research during the project will provide an improved understanding of the change to the understorey due to the thinning. As described on page 39 of the project document, the potential to encourage fewer but larger trees and a more open canopy may lead to slight changes in the local numbers of some herb, ground cover and understorey species. These slight changes are well within the range of natural fluctuations that occur on a local scale. In the longer-term (Section 2.22) the risk of weeds (Section 2.19) will reduce from the initial thinned state as the canopy closes and reduces the exposure of the understorey. As the forest moves towards a more mature structure in the decades after the 12-year Wungong project, the understorey is expected to be closer to that within an old-growth forest – which could be considered an improvement. Given the minor impacts on the understorey expected due to thinning are within local natural variability, habitat for small fauna is not expected to be measurably impacted. The project will increase fox baiting frequency, which will benefit small fauna. Also the trees culled with the cut-stump method will be left on the ground, and so provide habitat for small fauna. As with Section 2.16, appropriate monitoring will be used to check the impact on the understorey and fauna.
Answer	It is expected that thinning will have minimal impact on small fauna and forest understorey during the project, but monitoring and research will conducted during the project to better understand the impact.

2.21 Vegetation – species mix

Issue	Should thinning favour particular species?
Submission quotes	“pre-logging mix of native species should be retained as far as possible” “The intention is to favour marri over jarrah as marri is resistant to dieback, produces good honey and provides seeds for birds. This is unacceptable modification of the forest. The pre-logging mix of species should be retained as far as possible.” “The intention is to favour marri over jarrah as marri is resistant to dieback, produces good honey and provides seeds for birds and hollows for fauna (para 5.2.3, p. 40). This is unacceptable modification of the forest. The pre-logging mix of species should be retained as far as possible.” “... different species of trees are of differing frequencies within the same range; i.e. one thousand five hundred to two thousand Hz. This means that a diverse species within a forest will draw more rain than a monoculture. We need to look at which trees grow better in a given environment and the symbiotic relationship that they have with each other. There are chemical and energy exchanges between all species to the benefit of the tree community.” “Water Corp are proposing to retain more Marri trees than Jarrah trees and in doing so reduce the diversity further away from a pre-European Jarrah forest structure. The proposal to kill Jarrah, Marri, Balga, Banksia and Sheoaks whilst claiming that this will not reduce biodiversity, is similarly contradictory and worrying.”
Summary of issue	• Should not alter the mix of species from pre-European times. • It is unacceptable to favour marri over jarrah. • The project will kill jarrah, marri, balga, banksia and sheoak whilst claiming this will not reduce biodiversity. • Need to look at trees which grow best in a particular environment and with other species.
Response	The original project document stated that marri would be favoured over jarrah for a range of reasons include production of honey. There is no support of this option, including from bee-keepers. Some submissions have incorrectly stated the project will kill balga, banksia and sheoak – the focus is on thinning the overstorey species (jarrah and marri) and will keep key understorey species (with some treatment only if they regenerate out of a natural balance (Section 2.19)).
Answer	In response to the public review the project will not favour a particular native species when thinning. Within stands that contain introduced species, these will be culled in preference to local native species.

2.22 Vegetation – longer term

Issue	What is the long-term vision for the forest in the Wungong Catchment?
Submission quotes	“partial clearing intent is to reduce basal area ... and to keep it as that level ... somewhat less of the basal area of old growth forest and it seems that the intention is never to allow the forest to approach the tree cover of old growth forest ... this is not environmentally acceptable” “How long does it take for an area of regenerated forest to attain 'old growth' status?” “If there is adequate rainfall, after thinning the vegetative cover will tend to return to earlier levels. An increase in the undergrowth is likely with more light penetration and access to soil moisture depending on rainfall. In other words the system will tend to return to its own balance. It seems to us that the project proposes to keep reducing the total foliage cover. Discussion of foliage cover in terms of data on NDVI changes and modelling of scenarios would have been more convincing in showing expected changes.” “... run-off from the catchment has declined by 50 - 60%. In spite of these disastrous results for the now primary function of these catchment areas, the collection of water, logging in the catchment's regrowth forest continues with the largest trees remaining still being targeted. Yet at the same time the proposal is 'to change the structure of the regrowth forest in selected parts of the Wungong catchment towards that of a mature forest.' The logic escapes ...” “This trial is only a 12 year trial. Alcoa has been attempting to revegetate native species and Jarrah forest ecosystems for years with mixed success. Jarrah is a very slow growing tree. What if the negative effects of the thinning take longer than the length of the trial to become evident? We know that fungi plays an important symbiotic role in a Jarrah forest – we need to fully understand the long term effects that 'thinning' will have on fungi. CALM's attempts to improve the regeneration of Jarrah using gap creation have not been a success. Similarly, what will the impacts of reducing Proteaceous flora species on phosphate levels in the soil? The monitoring and assessment of the trial must be over a longer time span and the results of this must not be used to justify thinning in any other catchments until a longer period of monitoring has happened, if ever.”
Summary of issue	• It seems the intent is to never allow the forest to approach the tree cover of old growth forest, with large trees still being targeted. • How long does it take for a regrowth forest to attain old growth status? • Using scenarios of leaf cover indexes would have been useful. • Trial is only 12 years and jarrah grows slowly, so a longer trial is required prior to moving to other catchments.
Response	The description of the Wungong project has focused on the forest within the 12-years of the trial, but beyond the project as the forest grows after being thinned and tree diameters increase, the forest density will increase. To continue the forest being moved to a mature structure, which has a spacing

	between trees of greater than 10 m, beyond the 12-year Wungong project which is the subject of the public review, the forest may require re-thinning in 15–20 years. This second thinning would be to increase the spacing between trees further than the initial thinning that resulted in a spacing of 5–6 m. The forest basal area after the second thinning would be larger than after the initial thinning, because although the spacing between trees has increased the individual trees are much larger. This means the basal area would on average increase in time, but with steps down every few decades. The frequency of these steps due to re-thinning are expected to decrease in time. This process is not about permanently keeping the forest at a basal area of 15–18 m²/ha, it is about helping the forest move back towards a mature forest structure with fewer, bigger, more widely spaced trees. Because of the structure of a mature forest with less leaves per unit area than a dense regrowth forest – it will have a reduced transpiration and so allow more run-off from any rain that falls. It will take time for the current thinned regrowth forest to begin to resemble the characteristics of older growth. The thinned forests should begin to resemble the structure of older growth in about 50 years time. In another 80–100 years they should contain most of the attributes of older growth stands and will probably be indistinguishable to “old-growth” to the untrained eye. Once the catchment’s forest is moved back to a mature structure in many decades time, it will allow the maximum amount of rainfall to run-off from a healthily forested catchment. At this point, there is no need from a water supply perspective to remove trees except to help regenerate the forest, and what catchment management is appropriate will be for that future generation to decide using the Forest Management Plan public process. During the project, measurements will be taken of the forest structure inside and outside the catchment to help measure changes and better understand how the forest responds to thinning.
Answer	The long-term vision is for a forest with a high proportion of large, old, widely spaced trees.

2.23 Timber products

Issue	What timber products will be produced?
Submission quotes	"I notice in your summary that you refer to that target area as 'dense pole stand', such stands are highly sought after and created to meet pole requirements. The summary states that the area 'will be non-commercially thinning. What will happen to the thinnings?" "If possible, trees to be poisoned or otherwise killed should not be left as dead standing timber. Instead, commercial uses for this wood should be sought, even if the most likely use is as firewood collected by members of the public on what has been the traditional Sunday afternoon picnic for many Perth people who also take a chainsaw and trailer with them! The removal of fallen timber from the forest floor has serious environmental impacts which should not be allowed to continue in areas close to Perth where many areas of state forest are almost devoid of fallen logs. Accordingly, alternative sources of timber should be made available and the standing timber to be killed within the Wungong catchment is a possible alternative." "... objects strongly to the practice of logging or harvesting of forest products from bushland in a water supply catchment. Indeed it is clear that past logging of the Wungong catchment has been counterproductive to surface water yield. The catchment should never have been logged in the first place. Logging would also have helped to spread dieback, increase weed invasion, and disturb soil resulting in stream degradation." "on pg 72 under the heading 'Nutrition, carbon and biofuel' we find a tiny but important paragraph. 'In native forests the project does not anticipate the widespread removal and sale of firewood or bio-fuel from the thinned areas, though a small volume of higher-value products such as jarrah sawlogs and poles may be available for sale through the FPC, under the approved Forest Management Plan and CALM's logging plans.' (our emphasis) There is much cynicism already that this venture is a mutually beneficial arrangement between Water Corp and the FPC and this sort of thing doesn't help. Either it is openly and honestly not commercial or it is commercial even if only a small portion, in which case we want much more detail (ie how many logs, sold to whom, for how much)." "... considers the project to be a cautious approach to the management of the forests and advocates that all wood resource derived from the treatments should be made available to the relevant industry for harvesting." "... advocates the commercial utilization of timber products generated as part of the project. Under the Forest Management Plan 2004-2013 timber supplies from Western Australia's native forests have become quite scarce and this makes timber more expensive to WA consumers and increases timber imports. Every opportunity should be offered to the timber industry to conduct the Wungong catchment project operations within strict guidelines for the recovery of timber products and fire wood for domestic processing and consumption." "... we venture to propose a thinning regime that differs from that of the CALM one, but one that will result in more positive outcomes for both water and saleable by-products ... that takes out the most vigorous dominant trees rather than the suppressed, sub-dominants and over-mature trees, is

	proposed. The vigorous dominant trees have the largest crowns and hence use significantly more water and have the bowls that are more commercially attractive. Retained over-mature trees have sparse crowns and most hollows suitable for fauna habitats. This 'thinning from above' to the optimum basal area for water yield, removes those trees that use most water and would produce more saleable sawlogs at a lower cost and quicker response time for water yield. It would also avoid the costs involved in non-commercial poisoning and the ensuring fire risk that it creates."
Summary of issue	• What will happen to the thinnings as pole stands are highly sought? • Culled trees should not be left standing, rather used for public firewood. • Removal of fallen timber has serious environmental impacts. • Object to logging in water supply catchments, as it spreads dieback, increases weeds and disturbs soil reducing stream quality. • Cynicism about mutually beneficial arrangements between Water Corporation and FPC. • Project is a cautious approach to forest management and all wood resources from project should be used. • Alternative proposal is to thin from above.
Response	In forestry operations it is normal that the non-commercial thinning (the focus of this project) is done as a follow-up to a commercial harvesting operation. So if FPC is going to conduct a commercial operation within Wungong Catchment during the period of the project, there will need to be liaison between the Water Corporation and FPC to ensure the timing of work can be progressed logically. Any commercial logging operations and arrangements are the responsibility of FPC under the approved Forest Management Plan. Log sales will be to approved customers at royalty rates set by the Government and the volumes will be deducted from the approved sustainable yield. From a water perspective the Wungong project, as part of being sustainable, is economically viable. As a water source it is low in cost, as it uses an existing dam and pipelines. There are two methods of thinning planned for use in the project: stem-injection which would leave the culled trees standing, and cut-stump which would leave them on the ground (Section 2.16). The reason the thinning is called 'non-commercial' is the culled trees are too small to be sold for sawlogs. In the older mining rehabilitation there is expected to be some commercial products, as discussed in the project document. This would be thinning from below to help develop the forest over the longer term towards a more mature structure.
Answer	The current arrangement is to leave the trees in the catchment unless a third party develops their own proposal to use this wood.

2.24 Coppicing

Issue	How will coppicing be controlled?
Submission quotes	“Most eucalypt trees when felled are capable of coppicing and this would defeat the purpose of thinning to increase water run-off. It is likely that the same areas will need to be re-visited to remove the coppicing.”
Summary of issue	• Concern that coppicing following thinning will mitigate the water benefit of thinning.
Response	In past thinning research trials in the south west of WA, all but one catchment had no coppice control. Typically within a decade the streamflow returned to the pre-thinning level. In the case where follow-up coppice control was carried out, the streamflow increased again.
Answer	Proper use of an approved herbicide would reduce coppicing to less than 10% of treated stems.

2.25 Fauna

Issue	What fauna monitoring and management will be done?
Submission quotes	“As you know we have extensive data on vertebrates (especially birds) for the Wungong area including some field notes dating back to the 1960s.” “... Bungendore Park I now the best surveyed area of jarrah forest in the Perth metropolitan area and could provide useful comparisons with sites in the Wungong.” “Figure iii requires clarification in the 'Environmentally Sound' corner. For example, what is meant by 'protected areas' and 'improved habitat'? Perhaps some clarification can be provided as a footnote to Figure iii.” EPA Service Unit “The 2002 CSIRO book ‘Tree Hollows’ directly states that if you have to consider nesting boxes for a proposal, the proposal is unsustainable. The Water Corp has tried to mitigate loss of cockatoo habitat trees in the Perth Hills by installing nesting boxes and all that has used them are Brush tailed possums, pink and grey galahs and wood ducks. Similarly, if the proposal will not reduce biodiversity or negatively impact on native fauna, why would Water Corp need to consider either replacement nesting boxes or having to relocate fauna.”
Summary of issue	• There is extensive data on vertebrates, especially birds, back to the 1960s. • Uncertainty about meaning of ‘protected areas’ and ‘improved habitat’ on sustainability benefits diagram from project diagram. • Uncertainty about why nesting boxes are required if project is not expected to reduce biodiversity or negatively impact native fauna.
Response	As a project under the Forest Management Plan there are areas of formal and informal reserves which are protected from silvicultural treatment, such as stream buffers and fauna habitat zones. Within the project there is also an experimental control catchment which is protected from thinning. The thinning will help move the forest towards a more mature structure, with individual trees having bigger branches and when damaged these develop bigger hollows and at an earlier age, which is good for fauna habitat (Section 2.15). It will therefore improve the habitat. As the spacing between trees increases, there is a higher risk of predation of tree dwelling animals by foxes as the tree dwellers come to the ground to move between trees. An increase in fox baiting will help reduce this risk. The project is expected to improve the sustainability of the Wungong Catchment and to be overall environmentally positive, including for the fauna. However, there may be disbenefits to some components of biodiversity and the Water Corporation will fund projects with additional environmental benefits that mitigate the risk of any environment effects of thinning. This includes using nesting boxes where experts advise that they can add value.
Answer	There is good baseline data on fauna in the catchment from work by the Museum of WA and Alcoa. This will provide a base line for the fauna monitoring conducted during the project. Fauna monitoring will include

	trapping and observation for a limited number of hollow dependant fauna species and measurement of some invertebrates.
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2.26 Biodiversity

Issue	How will the project be managed for biodiversity?
Submission quotes	“The document is not about biodiversity conservation, although it could be more so.” “The whole issue of impacts on biodiversity is glossed over with vague statements and weasel words. The discussion on p53 is meaningless 'management' chatter.” “If the Water Corporation were to be serious about 'minimising adverse environmental impacts' it would ensure that there is no more bauxite mining in the catchment.” “We strongly object to the assertion by the Water Corp made throughout the Wungong Catchment Management Project document (WCMPD) that it is possible to ever fully restore the original biodiversity of an area after it has been either heavily logged (and/or thinned) mined, repeatedly burnt, diseased, planted with exotic species (causing changes to the soil structure, Ph, nutrient layer,) exotic bees are introduced, loss of keystone fauna species etc” “how can the Water Corp even make the claim to aim to ‘restore’ biodiversity when we don’t even yet know what the extent of the impacts of climate change will be?” "... recognises the studies referred to in the Wungong catchment project proposal which identify that forest thinning can be used to increase catchment yield without significant risk of detriment to native flora and fauna and spread of the disease caused by <i>Phytophthora cinnamomi</i>."
Summary of issue	• Biodiversity has not been taken seriously in the project document. • Encourages Water Corporation to ensure there is no more bauxite mining in the catchment. • Objects to claim that it is possible to fully restore the original biodiversity after heavily logged, mined, burnt, diseased, etc • How can you restore biodiversity if you don’t know the extent of the impacts of climate change? • Biodiversity will not be put at significant risk.
Response	The Wungong Catchment is far from pristine with a history of land-uses including forestry, farming and mining. Some areas have been logged and regenerated up to four times and a fifth of its area has been mined and rehabilitated. There is no longer mining or farming in the catchment. There is no old growth forest within the Wungong Catchment that is not in formal reserves. That said, the Wungong Catchment has an important ecology and the Wungong project is consistent with the Conservation Commission’s Forest Management Plan 2003–2014 which has a focus on conserving biodiversity. The Water Corporation never claimed that this project would fully restore the original biodiversity. There are challenges to managing for biodiversity outcomes when climate continues to change and the ecology responds. A comparison of flora and fauna monitoring by the project in control and treated areas will be useful in understanding potential changes caused by the climate.
Answer	Following from the issues raised and about flora (Sections 2.15 to 2.22) and

	fauna (Section 2.25) there is range of strategies that will be used to ensure biodiversity is taken seriously in this project. The project aims to implement treatments to increase streamflow while maintaining biodiversity values.
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2.27 Energy balance

Issue	Will thinning changing the local energy balance?
Submission quotes	“Clearing or thinning does not create water. More run-off implies less water either reaching the water table or passing to the atmosphere through evapo-transpiration. The latter would seem most likely ... the liquid water-to-water vapour transition has significant cooling effect due to the uptake of the latent heat of vaporisation. The energy uptake for 4 – 6GL of water is not insignificant ... Perth already has significantly hotter ambient temperatures ...” “... trees are diamagnetic and water is paramagnetic. So we have a living ‘tower of power’ – the trees with its roots (foundation) in the earth; its body (antenna) growing up into the biosphere – a diamagnetic structure with paramagnetic water flowing through it ... The interaction of these frequencies through the rain clouds cause the vapour to form droplets of water which follow the ‘line of least resistance’ back to Earth.”
Summary of issue	• Trees provide a cooling effect and reducing evaporation or infiltration will reduce this effect. • Magnetic energy from trees, and other sources, is responsible for rainfall.
Response	Energy comes in many forms from electrometric-radiation (radio, heat, visible light, ultra-violet and x-rays), magnetic, sound, movement, nuclear, gravity, electrical, chemical, thermal and mechanical. Catchments play a part in a flux of energy, in particular the energy that is within water that moves through the catchment in different phases (vapour and liquid). Thinning the forest will marginally reduce evaporation and so increase the infiltration to sub-surface flow (Section 2.13), which in turn will decrease the removal of thermal energy that would have been used to evaporate the tree’s water. In turn this would have the potential to locally increase air temperature that may enhance the growth of retained trees and maybe increase catchment air temperatures. In context the change in water balance is about 4–6 GL per year of extra streamflow (and hence reduced evaporation) which is approximately 4% of total evapo-transpiration. Other energy fluxes related to trees that may exist are unlikely to be affected by thinning, which is not an intensive vegetation change. Hence any potential changes to rainfall are unlikely, but as rainfall will be measure within and outside the catchment some analysis be can conducted (Section 2.10).
Answer	As the natural variability of distributed parameters such as temperature, rainfall and evaporation is much larger than the impact of this project, any change in cooling or other effect from changes to the energy balance from thinning, is not expected to be measurable.

2.28 Aesthetic values

Issue	How will the visual resources be managed?
Submission quotes	“ ‘Although more expensive, the cut-stump technique will be preferred around areas of higher public visitation such as major travel routes, walk trials and picnic areas. Alternatively a buffer will be left, and these areas will not be thinned. Further consultation with the public is proposed.’ This is similar to the buffers along roadways down south to hide logging operations and clear fells. Again this raises cynicism and suspicion – either Water Corp has nothing to hide and believes this is the best way to increase water run off, or it knows that the public would not find the sight of many dead trees acceptable and is trying to avoid public outrage. We are against the proposal anyway but if the Water Corp really thinks this is viable then why would it not sign those ‘treated’ areas along major highways and next to carparks, as a way of educating the public and encouraging them to conserve water. The public needs to be woken up to the importance of conserving water, why not show them firsthand just how drastic things are becoming?’”
Summary of issue	• Cynicism and suspicion that use of aesthetically appealing thinning near public areas is to try and avoid public outrage of less appealing thinning. • Suggestion that signage should be used to inform public where treated areas area to encourage them to conserve water.
Response	Public acceptability of the project will be based on the provision of scientific information and people’s perceptions. Visual amenity is part of the sustainability of this project, as it impacts on social enjoyment. There are two thinning techniques to be used in the project: stem-injection and cut-stump (Section 2.23). For a few weeks after stem-injection there will be dead leaves hanging off trees until they fall off, and this may not be appealing to some. A method of allowing the public to continue enjoying an area that has been thinned, is to use a cut-stump technique as a buffer between the stem-injected stand and public assess areas. With the cut-stump technique the culled trees are felled to the ground. This is nothing to do with hiding the thinning, as signage and conducted tour will be used to explain what has occurred. The Water Corporation has openly engaged with the community with this project (Section 2.31). It will also investigate social acceptability of the aesthetics of different thinning techniques during the project.
Answer	CALM’s visual landscape management guidelines will be implemented.

2.29 After Wungong

Issue	What catchment thinning will occur after the Wungong project?
Submission quotes	“any result from this trial cannot be used to justify similar tree killing in other catchments where the rainfall is lower, the soil and hydrological conditions are different and ecosystems are dissimilar to those in the Wungong Catchment” “Are conditions similar to the other dams supplying Perth, assuming that tree thinning will take place in these catchments after the Wungong Dam trial has been completed?” “the extrapolation of positive results from here [the Wungong project] to the other catchments may have the opposite effect (that is, the larger scale of the experiment may then cause reduced rainfall that is measurable)” “The Wungong proposal to get an extra 4-6 GL/yr of cheap water is the thin end of the wedge. The Water Corporation hopes to get an extra 40 GL/yr from killing trees in other water catchments. This proposal is not environmentally acceptable in the Wungong catchment or anywhere else.” "Any result from a trial in the Wungong Catchment could not be used to justify similar tree-killing in other catchments where the rainfall is lower, soil and hydrological conditions are different and the ecosystems are not the same as those in the Wungong Catchment." "Even if salinity is not a problem in the Wungong catchment, it may be a problem in other catchments, so results from any trial in the Wungong catchment cannot necessarily be applied elsewhere.” “Will this project be allowed to run for the projected 12 pilot years? Or will it be applied to the Mundaring Weir catchment area before the pilot programme has finished?” “As an experiment, I would also support the paving of part of a hill's dam catchment, provided that it was already devoid of native vegetation, e.g. if it was an Alcoa bauxite pit about to be rehabilitated.” “The Wungong proposal to get an extra 4 - 6 GL/yr of cheap water is the thin end of the wedge. The Water Corporation hopes to get an extra 40 GL/yr from killing trees in other water catchments (para 3.2.4, p. 14). This is not ecologically sustainable or environmentally acceptable in the Wungong catchment or anywhere else. Any result from a trial in the Wungong Catchment could not be used to justify similar tree-killing in other catchments where the rainfall is lower, soil and hydrological conditions are different and the ecosystems are not the same as those in the Wungong catchment.” “The ... does not believe that the proposal presents adequate evidence that runoff and yield is likely to significantly increase under the expected drying of our climate. Climate change is an over-riding influence. The proposal does not show how it calculates the extra 40GL/a expected. Loose wording suggests that it is based on the 1980's research where rainfall was higher and runoff much greater. It is clear that thinning does increase runoff but in this landscape surface runoff rates are not inherently high.” “Given that the experiment may run for 12 years, and that there will necessarily be a lag between implementation of thinning and water gains, how does the strategy of forest thinning fit into the overall long-term strategy for

	water supply in the Integrated Water Supply Scheme?" "How does the Project Team plan to regionalize the experimental results arising in the Wungong Study?" CSIRO Land and Water "Water Corp is now looking to thin out vegetation adjacent to dam areas. This is a step in the right direction, however you need to go much further to have any real impact. An area of land 50–100 acres (example only) needs to be cleared – then gravelled and compacted to form roaded catchments the same as farmers do to get water into their dams. This area would need to be calculated in relation to the dam area." "It sets a dangerous precedent. Who decides how many trees are removed, and what happens as the population increases and more water is needed, will they continue to remove trees?" "We are extremely worried that this is a trail that might be expanded to other catchments in the future. We have already experienced the Water Corp's thin end of the wedge approach to implementing what might be controversial. We were alarmed that this is a '...4-6 GL trial in the Wungong catchment is a pilot for a potential longer term 40GL water source'. ... strongly opposes the prospect of this happening in more catchments with bigger water retrieval targets – the potential for conflict of interests and no one agency accepting responsibility if things go horribly wrong are too high. Even with this trial – what is being used as a control catchment to compare what happens if catchments of similar disturbance are NOT thinned? Without this, won't all the findings will only be pseudo science anyway?" "... advocates that the catchments should be sustainably managed for water production as the first priority. The priorities for management should be: 1. Sustainable management of the forest for long term community benefits, 2. Water harvesting for high quality drinking water supply, 3. Public safety and protection of constructed assets and assets on neighbouring land from wildfires, 4. Conservation of flora and fauna, 5. Timber harvesting, tourism and other commercial and recreational activities and regional conservation targets" "The opportunity should be seized to encourage all property managers including farmers and pastoralists, at their own expense, without government involvement to be properly managed silvicultural, just as they manage the balance of their properties. This regeneration to the local flora would benefit the overall stabilization of ground-water and run-off and provide habitat for threatened flora and fauna, while benefiting farming problems such as salinity, erosion etc."
Summary of issue	• Results from this trial can not be used on other catchments, as conditions are different and wider scale thinning may reduce rainfall. • Are conditions in Wungong similar to other Perth catchments? • Will trial be run for 12 years or will work start in other catchments, such as Mundaring, before then? • Paved catchment trials should be done in areas already devoid of vegetation such as bauxite mine pits. • It is clear that thinning increases runoff, but in a drying climate the longer term 40 GL/year may not be achieved

	• Need to see how 40 GL/year figure is calculated. • How will results from trial be used for planning longer-term thinning, and how does the longer-term thinning fit with water supply strategy for Integrated Water Supply Scheme given the lag between thinning and water gains? • Advocates sustainably managed catchments with a priority for water production.
Response	The Wungong project is being done as a possible stepping stone to larger and longer-term catchment management through parts of the high rainfall areas of our catchments. This would not include most of Mundaring Catchment due to its low rainfall and hence salt risk. The aim of the project is to decide whether this type of catchment management has good environmental and water outcomes. One of the main reasons the Wungong Catchment was chosen as the trial location, was it was representative based on rainfall, landforms and site vegetation types of the high rainfall parts of other catchments. While there will need to be consideration of local condition when moving to other catchments and improvements made to prescriptions based on the Wungong project, the general results of the Wungong project will hold true. As the project progresses and knowledge is gained, this can be applied to related issues before the project finishes. For example, bauxite mining rehabilitation prescriptions could be altered as mining continues in other catchments, and the next Forest Management Plan will start in 2014, but drafting will commence some years before then. Other forms of catchment management have been raised in the public review. Roaded and bitumen paving of already cleared parts of catchments, such as bauxite pits, has been suggested as a way of gaining extra water from our catchments. The modification of bauxite pits to gather water has been trialled in the past, with some success. In general the Water Corporation is moving away from this style of water gathering, due to maintenance and potential water quality issues. Also the dual benefits of restoring streamflow and improve the forest, makes catchment thinning more appealing than a solution which doesn't have broader environmental gains. The calculations for how much extra water can be recovered in the Wungong project and the longer-term catchment thinning, are based on three decades of paired catchment experiments which include smaller scale thinning trials. A drying climate will reduce the amount of extra runoff generated, and past research in dryer catchments has been used to estimate the impact of future drying. With advances in climate and hydrological modelling skill and with knowledge gained during the Wungong project, better estimates of increase yields will be made. This work will be encouraged during the project. Currently the forested catchments are managed for multiple uses through the Forest Management Plan, although the main focus is on biodiversity and timber production. Past forest management had priorities for different values with compatible and incompatible secondary values. In the high rainfall areas the priority was for water production. A return to this approach has been suggested in the public review. With learnings from the Wungong project this

	approach will be discussed during the drafting of the next Forest Management Plan.
Answer	When Government, regulators and the community are satisfied that the Wungong project is successful in providing good environmental and water outcomes, then catchment thinning will be conducted in appropriate parts of other catchments.

2.30 Alternative water options

Issue	Should other water supply and demand options be done instead of this project?
Submission quotes	“We all need to be more aware of our water usage and availability.” “perhaps public should be paying the real price of water in order to modify its habits of water usage (and wastage)” “... with all this controversy going on about our Water Supply ... surely this urgent ITEM cannot go on dribbling down the DRAIN: WATER IS A LIFESAVER TO EVERTHING, and as TIME passes so rapidly, some immediate action much come from somewhere, NOT PLASTIC BAGS FROM THE ORD, BUT WATER THROUGH A SENSIBLE TYPE OF PIPE, SERVING AREAS, En ROUTE. From a Women’s point of view, this could be so practical” “It is hoped to get an extra 4-6 gegalitres (GL) a year of cheap water. We should be paying the real price of water and not trying to prolong the bad habits of the past.” “Adequacy of water supply is a function of both supply and demand. Reduction of the ever increasing demand is a much more appropriate approach in a situation in which future rainfall is uncertain and highly likely to be less. Reduction can be achieved through a slower rate of development and of population growth.” “The price of potable water supplied to Perth residents (and industry) is too low for people to seriously consider water conservation and reuse as viable options. The emotional appeal of having a small (1000 or 1500 litre) rainwater tank under a house’s eaves makes no economic sense when water sells for just 60 cents per 1000 litres. The Wungong catchment proposal is likely to cause the price of water to increase, albeit marginally, but this can only be a good thing when there is so much to be done to reuse, recycle and conserve what is a finite and over-utilised natural resource, especially in places such as the Gngangara water mound.” “Adequacy of water supply is a function of both supply and demand. Reduction of the ever increasing demand is a much more appropriate approach in a situation in which future rainfall is uncertain and highly likely to be less. Reduction can be achieved through a slower rate of development and of population growth.” “It is hoped to get an extra 4 – 6 GL a year of cheap water. We should be paying the real price of water and not trying to prolong the bad habits of the past.” “The ... believes inadequate attention is paid to demand management and its comparison with catchment thinning in the document. Whilst it is mentioned we would prefer to see details of investment in reducing demand in both domestic and commercial sectors compared with various scenarios of thinning by mechanical means with up to 60% less rainfall.” “The solution to increasing demands for water is not to try and ‘catch’ more water but to use (and recycle) the existing water we have in a more appropriate and sustainable ways. The Water Corporation and Government should vigorously promote better use of existing water through measures such as: a. encouraging domestic water tanks to use run-off from gutters. Compulsory rain tanks for new homes – these could be underground and

	unobtrusive if required. B. recycling of grey water for garden use. C. encouraging use of low water use / native gardens. Making lawns 'unfashionable'. D. Tax incentives to promote the above measures." "There is no necessity to thin vegetation. It is a case of providing more catchment areas and reservoirs to collect more rain fall, rather than find ways of filling existing reservoirs." "It is a fact of life that Australia is a dry continent. Rationing or conserving water use cannot be an option. Collecting more water is the only solution to its growing demand. There is still a large inland desert that needs to be and can be greened. The solutions have been around for 100 years that I know of. In my lifetime there has not been the leadership foresight nor the will to do what could be done, that must be done or the least, tried." "If water is in short supply, more reservoirs can be constructed." "Meat eating is also a threat to water supply and agricultural scientists the world over are encouraging vegetarianism as meat eaters consume the equivalent of about 5000 litres of water a day compared to the 1000–2000 litres used by people on vegetarian diets. It takes 1790 litres of water to grow a kilogram of wheat compared to 9680 litres of water for the same weight of beef. According to the ABS report 'Water use on Australian Farms', Agriculture uses 70% of Australian's water and WA reported the highest average application rate 6.5 megalitres per irrigated hectare. So instead of again making our fragile eco-systems the scape goat yet again and making even more native animals extinct and wiping out their habitat its time to blame ourselves for our shrinking water supply. The Gallop Government should immediately cap WA's population, not increase it by another 750000 water guzzling humans, and stabilise the population urgently, not open up more land for housing developments, and drastically reduce the export of wheat, sheep, cattle and other grasing animals before banning it completely within the next two years, and so save water by limiting all water using Industries and live in a sustainable way by having a sustainable population." "... believes that there should still be much more emphasis on water conservation and reuse both domestically and industrially. Given that 90% of water is used by industry this is where the emphasis must be. Industry must be required to both use less water and investigate its own water reuse. We believe that there must be much more emphasis on educating people about reducing water greedy Eurocentric attitudes and habits in our low rain fall climate. We must deter people from growing non-endemic water dependant gardens and lawns and instead encourage daily water use reductions, grey water reuse and composting toilets. Rain water tanks should be included in all new houses and heavily subsidised for existing houses. If all West Australians, reduced water use in some of the ways mentioned above, and industry was required to do the same, then we would not have to be looking at proposals like this for ways to solve the WA's water crisis. With this proposal an obvious conflict of interest again becomes apparent, if people really did drastically reduce water use and consumption, Water Corporation would make less revenue. This proposal risks reducing precious native biodiversity, further deteriorating an already degraded catchment, and further degrading air and water quality as a way to make the Water Corp a relatively cost effective (for the Water Corp) return that could if all the impacts were taken into account, prove costly in the long run. The effort to educate people and resource the needed changes must come from all levels of government
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	including and possibly most importantly at the local government level.”
Summary of issue	• There needs to be more transparency about water usage and pricing, including for large users, in particular as industry uses 90% of the water. • Water is very important and should be piped from the Ord, supply areas en route. • Paying the real, higher, price for water to reduce water use. • Wungong catchment project will marginally increase the price of water, which is good as it will encourage water reuse and recycling. • Water use should be reduced by slowing development and population growth. • Thinning is not required, it is better to build more reservoirs to collect more rainfall.
Response	No single water source or water efficiency project will of itself solve all the water problems due to a growing population and a drying climate. The Wungong project is one of the Water Corporation’s diverse range of solutions to maintaining a water supply–demand balance. Other projects include recycling treated wastewater for industry, reducing per capita water demand, seawater desalination, new groundwater and surface water sources and improving the efficiency of irrigation systems to allow water trading. The Corporation is working with the community and industry on this range of projects. This includes incentives from the Government to encourage use of garden bores, in-tap flow regulators, rainwater tanks, soil wetting agents, tap timers, water efficient showers and washing machines, and increase greywater reuse. To complement the Government incentives, the Water Corporation has an extensive Waterwise Schools Program to educate students about using water wisely. But management of water demand will not solve the water situation by itself, and supply augmentation options need to be pursued. All water supply and demand projects have potential pros and cons. With the challenge of a drying climate and increasing population, even with significant demand management, the water supply will need to be increased. Catchment thinning is one of many water supply options, and will complement other projects. It is not a matter of either doing catchment thinning or do another project. The challenge is large enough to need tackling on several fronts.
Answer	Other water supply and demand management options will be progressed at the same time as the Wungong project to give customers security through diversity. The knowledge gained from this project is vital for guiding the future management of our catchments in a drying climate, so the Wungong project needs to proceed.

2.31 Involvement and decision making

Issue	Was the consultation during the project development and the public review adequate, and how do people want to be involved during the project?
Submission quotes	“proposals for further research ... some of these would mesh well with our Cookatoo-Care program but others are quite separate, however we feel that they will greatly benefit the project.” “...we would be very keen to be involved with the project.” “regarding the monitoring of water ... what if the community (and regulators) are not comfortable with the environmental and water outcomes of the initiative? Who are the stakeholders?” “More consultation of the community with public meetings to encourage debate on this project would ensure a balanced view from the whole Perth community. Needless to say we will be watching the development and monitoring of this project very carefully and we thank you for the opportunity to comment on this project.” “I have seen the ...'s discussion points to be used against many aspects of the Corporation's proposal and, to be quite frank, I am extremely disappointed at the emotional, non-scientific basis for most of the points they are encouraging people to use in their submissions to you. Their suggested submission points deserve to be carefully and very publicly rebutted by the appropriate experts and authorities who have contributed to the Wungong catchment proposal. In particular, I do not accept the ...'s claim that 'permanent partial clearing of the catchment ... is not ecologically sustainable'. Sustainability as a doctrine to be followed by society is no longer just about the environment; it must include economic and social considerations. On this basis, I conclude that the Corporation's Wungong catchment proposal can be made sustainable if this is accepted as being an important end goal.” “‘Sustainable management of water services' cannot 'make' Western Australia a great place to live. At best it can 'keep' WA a great place to live, which it currently is.” “The public is not told who gets how much water for what purpose and at what price, so there has been no public discussion of these issues and no public involvement in the decisions.” “Given that Environment Minister Dr Judy Edwards said that ‘thinning’ and burning in south-west catchments to increase run-off were already being carried out (media statement, 29th March 2005), the relevance of the proposed Wungong trial must be questioned.” “The concept of sustainability is not treated seriously in the document. Sustainability has become a fashionable buzz word generally used to justify activities which are not truly sustainable or to make 'business as usual' sound good. For example the phrase 'to achieve sustainable outcomes' is meaningless. Sustainability of what? We would prefer to see the document written in plain english. For example it is really all about increasing the runoff and hence yield of water from the catchment into potable supply. And this is a reasonable objective.” “Streamflow data should be more comprehensive” “... we appreciated being given all the information. However ... members are uneasy about the proposals.”

	“Consideration should be given to broadening the membership of the technical reference group described in Section 5.6.3 to include representatives from Universities, CSIRO and interested community groups and perhaps other stakeholders that were involved during the development and consultation of the project” EPA Service Unit “I understand from the media release of 26 April 2005 that public comment is invited until 8 June, however neither your [Ministerial] website nor the EPA website has the required information on the consultation process.” “We request that all questions and doubts raised by the community during this submission process be fully, comprehensively and publicly addressed by the Water Corporation before any final decision about any actual killing of trees is made.” “Concern about how water is collected and used is high on the public agenda. ... attended the Water Forums in 2002, and the proposal to ‘thin’ trees within catchments was never put forward for public discussion or consideration. Why not? Did you suspect then that the public would be strongly opposed. We thought this bordered on sneaky – you were obviously considering this proposal back then, why choose not to debate it publicly alongside the other options for water supply? We also attended a presentation held at the Conservation Council at which there was strong opposition to the idea of thinning in water catchments. Given the extent of community concern, it is imperative that more avenues for community discussion be facilitated and resourced by Water Corporation. Lengthy documents to which community is only allowed to provide comment is not consultation and does not adequately involve or engage the public. Also in the forward it is stated that the Water Corporation will continue to openly engage with the community and peak organisations, but in the community Consultation section of the document it talks about how they have had consultation with the key stakeholders and community, but no where does it give any solid examples of how it will continue to openly engage with the community and peak organisations. On page 54, 5.6.3 Monitoring and Research, it states that a ‘technical reference group will include CALM, DoE, FPC, Alcoa and Water Corporation has been formed to help develop the project and will continue to review the integrated annual works program...The membership of the group will be expanded to include the Conservation Commission of WA.’ Why is the community not part of the technical reference group – we request that this be immediately remedied to include at least two community non-government representatives. If the Water Corp is serious about including community as an equal stakeholder why aren’t they included in the technical reference group. In the last paragraph of the foreword, it is stated that this document serves as a contract between the community and the Water Corporation. A contract is something that all/ both parties need to agree on. If this document is the community’s chance to comment on the proposal, then how can the community agree to something that they have not yet commented on?”
Summary of issue	• There are opportunities for collaboration. • Uncertainty about decision making process and who is involved, but also that best science is used for decision making. • Desire for involvement, in particular representation on reference groups, but using accessible language and methods.

	• Desire for an open inclusive process and suggestions that this has not been the case in the past.
Response	Catchment management for surface and groundwater sources has been a water supply option for many years, and been discussed with the public during the consultation for Perth's Water Future during the early 1980s and again in the Water Forums during 2002 leading to the a State Water Strategy being launched by the Premier in 2003. There has been extensive consultation for the Wungong project from May 2002, which is described in the project document, and this recent public review is another step to better inform and involve stakeholders, to help improve the project. It is critical for the project that the community and regulators are part of the journey for this 12-year project. It is also important to understand the roles of those involved and who is going to make which decisions, so those participating understand the scope of their involvement. Decision making for the project is described in Section 3.3, and in summary the Water Corporation project manager is the key day-to-day decision maker with the Corporation's executive being the final decision maker. Stakeholder input will be sought at many review and decision making points in the project to provide advice to the Water Corporation. This will include being informed through a range of mechanisms, involved with workshops and field trips, and directly participating in research and potentially on-ground work. The process for how the community and regulators will provide advice to the Water Corporation on the success of the project, will be designed in consultation with stakeholders within four years of the project starting on-ground work. The Water Corporation is aiming for an open and transparent project. To help this, a community and research representative will be appointed to the project's Technical Reference Group. The community representative, probably selected from a community member of the Conservation Commission, must be able to contribute technically to the group.
Answer	This public review is considered to be adequate, building on 3 years of project consultation, confirming most aspects of the project and providing additional value adding information. Adequate opportunities will be provided for stakeholder and public review.

2.32 Approvals

Issue	What approvals process is being used?
Submission quotes	“... the EPA supported the approach of providing environmental advice on the Wungong project by way of Section 16 of the Environmental Protection Act 1986. This is on the understanding that the project is consistent with the Conservation Commission’s Forest Management Plan 2004-2013 (FMP) and that Water Corporation will be undertaking considerable public consultation to address any community concerns and perceptions regarding this project.” “In addition to the above comments, it is also requested that the project document include an additional section to describe the legal framework and approvals processes that are available under the FMP to ensure the Wungong project is implemented and operated as proposed in the project document.”^{EPA Service Unit}
Summary of issue	• Section 16 of the Environment Protection Act is being used for the public review. • Further project approvals will be under the Forest Management Plan and need to be described.
Response	The project document and the output from the public review, which is this report, will be provided to the EPA to help them provide advice under Section 16 of the <i>Environmental Protection Act 1986</i> to the Minister for the Environment. Subject to this advice from the EPA, on-ground work is expected to start in Spring 2005. The project is consistent with the Conservation Commission of WA’s Forest Management Plan 2004–2013, which means that before access is given to conduct on-ground work in a particular area of forest, approvals are required from CALM. The Water Corporation will arrange for these approvals to be obtained which include consultation with adjacent neighbours and environment checks. The first area to be treated is described in the project document and is in the south corner of the catchment. Before CALM approval for access for harvesting or road construction in any State forest or timber reserve, the main issues to be addressed (FPCI09) include: reserves or proposed reserves compatibility; Forest Management Plan land purposes; compatibility with other land uses; rare and threatened flora and fauna; other flora values or threatened ecological communities; spread or impact of <i>Phytophthora cinnamomi</i> or other pests and diseases; Aboriginal or European heritage, and native title; research or inventory plots protection; soil management; visual landscape management; rehabilitation/regeneration after project; fire management; stakeholder management; and safety.
Answer	The Forest Management Plan approval process is being used.

2.33 Monitoring

Issue	What monitoring program is required to assess project impacts?
Submission quotes	“It is possible that thinning would increase the concentration of NOM [natural organic matter] in the dam water because of the associated leaf-fall. This has the potential to in turn increase levels of disinfection byproducts (trihalomethanes & other DBPs) in drinking water once chlorination has taken place. Exposure to DBPs carries a very small individual health risk that includes adverse outcomes of pregnancy, but because of the very large population that is potentially exposed this could be a significant issue. The inclusion of additional monitoring with the routinely collected water quality parameters would protect consumers from unnecessary exposures: again, it is a strength of the IWSS that the dam can simply be taken off line while any emerging problems are dealt with.” “careful monitoring and hygiene precautions will be needed to avoid spreading dieback” “Further details and explanation of the monitoring and research components of the project will be required. This includes further defining the Key Performance Indicators (KPIs) described in Appendix I. Ideally the Water Corporation would develop a set of auditable KPIs tailored specifically for the Wungong Project rather than reproducing the KPIs from the FMP.” EPA Service Unit “How will the Water Corporation monitor the impacts on biodiversity from the thinning versus the impacts on the biodiversity from any potential logging, and how will the cumulative impacts from each be ascertained?” “... we insist that comprehensive fauna on the ground surveys (ie not just desktop surveys) be undertaken prior and during all stages of any proposed thinning to establish the presence of various species and the species richness of various species. Particular attention must be given to fauna in the area given that more than 5 Fauna Habitat Zones planned within the catchment. Similarly, comprehensive on the ground (not desktop) flora surveys should also be conducted before and during any proposed thinning, and these must take place during each season to assess the lifecycle of various species. How can we know what biodiversity we are losing or not, if we don’t know what was there in the first place?”
Summary of issue	• With the current good understanding of expected system response there is a good basis for developing a monitoring program. • Detailed Key Performance Indicators should be used based on the specifics of the project. • Monitoring needs to be field based and conducted before and after thinning.
Response	An important reason for choosing the Wungong Catchment as a location for the trial was its extensive history of monitoring flora, fauna and water parameters. This is due to the work of Alcoa and the water industry. As well as monitoring to provide specific information about the Wungong Catchment, general research into land-use impacts including thinning, across many catchments in south west WA has provided a good knowledge about how the Wungong Catchment will respond. This has helped to design an appropriate

	monitoring regime for the trial. Field monitoring at representative locations will include measurements taken before and after work is carried out. Monitoring will include streamflow and water quality at several points in the catchment (based on gauging stations with automated pump samplers and grab samples), and flora and fauna surveys (including flora transects at various parts of the landscape). The details of project specific Key Performance Indicators (KPI) will be developed on consultation with CALM as part of arranging a contractor for on-ground work. These KPIs will include project process and project outcome measures (for environmental and water parameters). The areas these KPIs will cover are described in the project document and these will be reviewed annually.
Commitment	Monitoring is a key part of adaptive management (Section 3.4) and new stream gauging stations and flora and fauna transects are being established to ensure the response of the trial is understood.

2.34 Research

Issue	What research is required to address the complexity of the project?
Submission quotes	“Will the experiment protocol as drafted be able to tease apart these factors apart?” CSIRO Land and Water “Because there are so many different kinds of disturbances it will be very difficult to identify the impacts of any one in isolation from the others. Also how will you be able to identify what is causing water run off increase, if there is any? If there is removal of pine at the same time as thinning of native trees, how will Water Corp determine which is responsible for how much water run off increase?” “... does not support this proposed trial, but if it were to go ahead, in the name of good science there needs to be some kind of control area within the proposed trial area, as well as in a similarly disturbed catchment, where thinning does not occur to compare with areas thinned and to be used as some kind of base line. This is especially important given we cannot predict the impacts of climate change let alone the combined impacts of climate change on an already degraded landscape.” “... believes these objectives can be serviced through existing forest science. The ... believes there is sufficient forest science available to justify the silvicultural and fire management treatments proposed as trials in the project. The ... considers the project very cautious and would advocate early adoption of the project over wider areas of catchment.”
Summary of issue	• The impact from particular land-uses and treatments are difficult to determine when they interact in the one system • Control areas are required to compare the impact of treatment to non-treated areas
Response	Catchments, like all natural systems, are complex and challenging to understand. Research will be used to understand more fundamental questions than can be determined just from the simple analysis of monitoring data. There is wealth of understanding about forest and water science to ensure the project has a high chance of successfully providing good environmental and water outcomes. Catchment thinning research in the past has focused on the water response, with less research on the ecological aspects. Hence ecological research will feature more prominently than water research for this project, although there are several water related questions that will be addressed (e.g. Section 2.13). Hydrological computer models with inputs from field measurements may be able to help attribute catchment responses to particular land-uses or treatments, but even if this is not entirely possible, the response of the whole catchment management project can be assessed. Detailed field work to measure the movement of water in single trees and remote sensing to look at forest scale water stress will be used to improve our understanding. Some of this work will be conducted in partnership with Alcoa using university researchers. Within the Wungong Catchment, the Waterfall sub-catchment has acted as a control for past research in the catchment related to understanding the impact of bauxite mining and rehabilitation. This sub-catchment will act as a control

	for this project, along with information draw from nearby catchments as well as some untreated areas. Seldom Seen and More Seldom sub-catchments were used in the past to understand the impact of bauxite mining and rehabilitation. These will not be treated under this project for about five years to provide further comparative data.
Answer	Section 3.2 describes the approach to funding and facilitating research.

2.35 Project overall

Issue	On balance should the Wungong project proceed?
Submission quotes	“The Department of Health supports the proposal on condition that: [there is no negative impact on water quality and only approved chemicals are used, see Section 2.6, 2.7 and 2.8]” Department of Health “... you will forgive my immediate of scepticism when confronted with a document apparently trying to increase runoff by cutting down forests in catchments. I am pleased to say that having now read the document in more detail, I am a convert!” “The material is excellently presented and honestly balanced (as far as I can tell) to provide an argument that is very convincing. Whilst based on the best evidence available, scope has been left to make adjustments as new findings come to light, and this is good science.” “I wish to recommend considerable caution regarding this project” “Overall it looks a good but ambitious plan ...” “while I am obviously not comfortable with thinning the trees so drastically, although the coppiced ones do need to be done, may I congratulate you and the Water Corporation on the amount of preparation and research that has been done and the magnificent presentation of the project document.” "the Wungong trial is likely to prove successful (in terms of stream runoff as a proportion of catchment rainfall)" “I have not had a chance to review the proposal, however I do not believe this is the correct way of addressing our water issues. I include the following points raised by the Conservation Council, as my concerns and objections to this proposal” “... our members note that it aims to achieve sustainable management of water services which include actions which must be environmentally sound, socially responsible and economically viable. Unfortunately we have certain misgivings that this project may not meet those standards.” “The proposal has significant merit and deserves to gain government and community support for a number of reasons. In particular, the area of catchment to be thinned has been poorly managed in the case of historically logged native forest or inappropriately revegetated in the case of many of Alcoa's mined bauxite areas. Accordingly, the Corporation's proposals will have little adverse impact on natural environmental and conservation values within the subject area.” “It is in fact permanent partial clearing of the catchment by repeated killing of trees to provide cheap water for human use. This is not ecologically sustainable or acceptable.” “The project proposed is a continuation of various disturbance practices.” “The Wungong proposal is presented as a trial when it is really a forest management plan for 12 years for the whole catchment in order to increase water yield and production of commercial forest logs (see p 44), and to continue bauxite mining. This is akin to the Japanese rationale of whaling for research purposes.”

“The overall thesis, that both water yield and forest ecosystem health might be enhanced with appropriate thinning, is highly plausible and an experimental approach such as proposed appears sufficiently justified. At this broad level, we have identified no flaw of logic or incorrect statement of fact in your proposed project, and strongly support the intent to further elucidate the potential benefits and risks in a long-term study in a catchment such as the Wungong.”

CSIRO Land and Water

“I am encouraged with your proposal regarding water and environmental management in the Wungong Catchment Project. There are many challenges ahead to provide both sustainable water supplies and the environment in such a difficult rainfall climate”

“Thinning of vegetation in a water catchment to increase water supply is not environmentally sound, is contrary to the State’s sustainability policy and appears to be seeking to address the symptoms of water shortage as opposed to the cause.” “...we do not support the proposed project and would urge you to consider a more sustainable and practical solution to water supply and demand in the region”

“No amount of regrowth manipulation will make any real difference to the water supply problems ...”

“... strongly objects to the proposed ‘thinning’ (what a euphemism) of native vegetation specifically within the Wongong catchment and is opposed to any further clearing of any NATIVE vegetation within water catchment at all. We do however support the proposal by the Water Corporation (Water Corp) to replace pine and other exotic flora species with native species.” “We have grave concerns that it will therefore be very difficult to get any of the agencies involved to accept responsibility.” “If climate change keeps reducing rainfall then no amount of catchment thinning is going to solve the problem of water shortage in the long term. The analogy that comes to mind is the golden goose – if we are not careful we could end up with nothing – no overall long term increase in water, a loss of biodiversity including unique native flora and fauna, and a decline in water and air quality and other ecosystem services.” “We should not be further degrading the natural environment to source more water, instead we need to focus on reducing human over consumption. The problems faced by this catchment are all human made – mining, disease, logging, exotic species changing soil conditions, a dam, etc. We need to stop trying to address existing disturbances with more human centered disturbances. The extent of degradation to date surely proves that we do not yet understand the environment enough to know how to avoid degrading it further. Salinity is another prime example of this.”

“... Is strongly supportive of the Wungong catchment management project. It is a very cautious proposal and the ... encourages early extension of the trials into wider management of jarrah forest catchments west of the salinity risk zone. Every opportunity should be taken to commercialise the operations to maximise the utilization of timber products grown in the forest.”

“Your concept of increasing water run-off on catchments by forest thinning is a good one. It involves a principle of silviculture appropriate to the area that should be universally applied by all property managers in Australia.”

“We take this opportunity to congratulate the Corporation for showing the

	foresight and courage to tackle the sometimes-vexed issue of improved water catchment management. It is with please that we learn of your decision to conduct the trial thinning of native forest regrowth in the Wungong catchment with the aim of increasing the quantity and quality of water recovery.”
Summary of issue	• Conditional support. • Initial scepticism to supportive. • Ambitious and brave. • Caution required. • Likely to succeed. • Significant merit and deserves to gain Government and community support. Little adverse impact expected. • Not ecologically sustainable. • Akin to the Japanese rationale of whaling for research purposes. • No flaw of logic or incorrect statement at a broad level, and strongly support intent to understand benefits and risks of this project. • Encouraged by project and there are challenges ahead in a difficult rainfall climate. • Not environmentally sound and contrary to State’s sustainability policy and do not support project • No amount of regrowth manipulation will make any real difference. • Strongly object and have concerns agencies wont accept responsibility. • Strongly supportive, although the project is a cautious proposal.
Response	There is clearly a wide range of opinion about the project, from opposed to cautiously optimistic to supportive, but this review is not about a popularity poll, it is looking for technical issues. The issues need to be assessed in a economic, social and environmental framework. This framework also needs to consider risk as the plan contains uncertainty. There is some uncertainty about the future climate, although it is likely to be hotter and drier, and there is uncertainty about potential benefits and negative impacts. Past research and management frameworks provide comfort there is expected to be benefits for the environment and water, and that there is a low risk of potential negative. The review has not identified any fatal flaws in the project. So if the negative risks are considered reasonably low and potential benefits are considered worthwhile, then the only way of reducing uncertainty is by conducted the research trial.
Answer	The public review has identified a range of views from the strongly supportive to those strongly opposed to the project. The Water Corporation believes the project is necessary to test this catchment management strategy in a drying climate, and it should proceed.

3 Implementation of the project

3.1 Scope of project

The Wungong project is made up of three broad areas

1. On-ground work including silvicultural treatments.
2. Understanding through monitoring, auditing and research.
3. Involvement, communication, decision making and adaptive management.

The items above are all linked, but are in a hierarchy with the final item being supported by the others. This means communication events and decision making, such as annual reporting and 4-yearly reviews, need to be supported by on-ground work and useful monitoring/research data.

From the public review, the critical implementation issues related to research, decision making and adaptive management. These three are described in Sections 3.2 to 3.4, with the whole implementation described by a list of commitments in Section 3.5 which is a revised version from the project document based on feedback from the public review.

3.2 Research

There is a continuum between monitoring and collection of base information, through auditing and then research. Research focuses on answering more fundamental questions about a system, in this case the ecosystem function and the effects of management practices in the Wungong Catchment. The Water Corporation identified research topics in the project document and the public review provided guidance to the community's interest. The structure of the research will be

- Funding from the Water Corporation, partners and Federal Government, e.g. Australia Research Council (ARC) linkage grants.
- A program of research projects integrated across different science disciplines, with the entire program preferably being the subject of a series of ARC linkage grants.
- Program designed with other funding partners where possible.
- Projects within program conducted by Universities and other research providers.
- Research co-ordination, including communication, by either a senior researcher (such as a post-doctoral researcher) or Water Corporation officer.
- Individual projects are peer reviewed by their publication in respected journals.
- Research program is reviewed as part of the four yearly review.
- Program is phased with some projects such a honours running for one year, masters for 2–3 years and PhD 4–5 years (until thesis finalised), plus other work by research staff that continues over the entire 12-years of the Wungong project.
- Program supported by the Water Corporation with monitoring data and integration (e.g. workshops annually of all researchers, and ongoing communication between groups).

The next round of ARC Linkage grants is due 26 November 2005 and the first phase of a research program needs to be submitted by then. Funding from a grant, if successful, will not be available until July 2006, and then there would be several months until researchers can be selected and start work. Subject to advice from the EPA, non-commercial thinning within Wungong Catchment is

expected to start in the first treatment area in Spring 2005. Hence monitoring and contract research will be required to start collecting some of the baseline information concurrent with work starts on-ground and funding is available in the 2005/06 budget.

3.3 Decision making

Decision making is tied to responsibility. The organisation or person with responsibility will make a decision with the input to that decision involving a range of people. During the 12-year Wungong project, the Water Corporation will be ultimately responsible for making final decisions in its areas of responsibility, subject to regulatory constraints. At the end of the project, its success will be decided with input from a public process that shall be designed by the Water Corporation in consultation with stakeholders within the first four years of the project starting.

Land management is a key responsibility related to the Wungong project. Most land in the Wungong Catchment is vested with the Conservation Commission of WA and managed by CALM. Also DoE and Water Corporation have some land vested with them, and within the areas that have been mining and rehabilitated Alcoa still have responsibility for the land. This makes Conservation Commission of WA, CALM, DoE and Alcoa tied to some decision making for the project; and they are partners rather than stakeholders.

The public review confirmed stakeholders are interested in being involved. The level of involvement ranged from being regularly informed, through to participating in research. Stakeholders include the community, non-government organisations (in particular environmental), industry, government departments (including regulators) and local, State and Federal government. If the community and regulators are going to be able to give advice during and at the end of the 12-year project about the project's success, they need to be involved throughout the project. Involvement includes understanding the objectives and targets of the trial and progress in meeting them; being informed through bulletins, a project web-site and field trips; and participating in workshops, reviews and representations on the technical reference group.

The key decision maker for the Wungong project is the Water Corporation Project Manager, who is supported by a project team and will take advice from stakeholders, in particular the Technical Reference Group. The Project Manager runs the project and makes day-to-day decisions, including periodic changes to on-ground works, monitoring and research programs. The contractors for on-ground parts of the project and researchers may also have their own project manager.

The Technical Reference Group membership will be expanded to include a research co-ordinator and a technically qualified community representative. This group will provide peer review of monitoring analysis and research outcomes to help guide the Project Manager. The Policy Reference Group will continue to sit above the Technical Reference Group. This high level group has representatives from the organisations that have responsibility for certain aspects of the project.

The Water Corporation Executive has over-sight of the project and makes critical decisions at the 4-yearly reviews, which include whether to continue the project or not – based on its success to that point in meeting project, environmental and water targets. These important decisions will take account of project audits and an independent review of the project and input from stakeholders through workshops.

Stakeholders will be encouraged to provide input through direct communication, participation in field tours and workshops and through representatives on the Technical Reference Group – as this input is vital to help guide the project. The Project Manager uses feedback from these methods as input to the project's adaptive management.

3.4 Adaptive management framework

The Wungong project will be managed by the Water Corporation under the requirements of the Forest Management Plan. This plan provides the principles and guidelines, but at a more detailed level there are decisions that will be made during the project to improve water and environmental outcomes. This adaptive management process will be based on feedback from stakeholders, analysis of monitoring, auditing and research. There are four areas for adaptive management during the 12-year project listed in Table 1. The areas for adaptive management listed are ranked. The first area is the least likely to change during the project and would require the most analysis and consultation before being changed, compared to the last area which is expected to change the most frequently to adapt to faster changing issues.

Table 1. Decision making within adaptive management

Rank	Adaptive management area	Review period	Decision making process
1	Objectives and performance measures	4 year	Project Manager to arrange - Independent project review including stakeholder interviews, audits, technical and sustainability assessment (environmental, economic and social) – presented to the Water Corporation Executive. - Two 1-day workshops (community and technical) using project review as a discussion paper. Water Corporation Executive - Decide, with input from an independent review and workshops, to continue, amend or stop the project. - Report to partners, stakeholders, public (through web-site), and Conservation Commission for consideration in its adaptive management process and in the next 10-year Forest Management Plan.
2	Gaining understanding: monitoring, auditing and research program	1 year	Conservation Commission - Audit silvicultural treatments. - Report to Water Corporation and EPA. Project Manager to arrange 1-day review of monitoring and data management by those involved in collecting data 1-day stakeholder workshop with research presentations - Changes to programs or KPIs as required based on audit and workshops. - Annual report by project team to Conservation Commission with distribution to stakeholders and website
3	Implementation: prescriptions and	monthly	Project Manager with contractors to Arrange on-ground work, including obtaining the approvals required by CALM

	contractual arrangements		to access land. b. Monitor performance and exceptions. c. Keep project on target including on budget. d. Collate project key performance indicator data for annual report.
4	Communication strategy: methods and events	ongoing	Project Manager to maintain and implement communication strategy: a. Consult with neighbours adjacent to treatment areas. b. Maintain stakeholder distribution list and promote project to broader community. c. Regularly update web-site and liaise between stakeholders. d. Monthly project team meetings. e. Presentations and meetings as required with stakeholders. f. Technical reference group meeting, at least 2 per year. g. Project bulletins, at least 3 per year. h. Stakeholder and technical reference group field trips as required, at least one per year. i. Research collaboration workshops as required, at least 2 per year. j. Act on feedback during year and collate analysis in annual report.

3.5 Water Corporation project commitments

#	Topic	Actions	Objectives	Timing	Sources of advice
1	Biodiversity	Implement management techniques such as: • no non-commercial thinning in stream buffers or heathland; • minimal fragmentation of habitat; • control of exotic and weedy species; • no removal of larger debris from forest floor; • retention of the larger trees with greater potential for hollows; • retention of key components of the understorey; • increased fox baiting; • evaluation of the feasibility of feral bee control and provision of nesting boxes; and • trial the under-sowing of native species in plantations of exotics.	Minimise any adverse effects of non-commercial thinning on biodiversity.	Throughout project.	Conservation Commission CALM Serpentine-Jarrahdale Shire Alcoa Conservation Council Academia
2	Forest Management Plan	Ensure project's management plan is consistent with the Forest Management Plan objectives and intent. Contribute data to relevant Forest Management Plan key performance indicators.	Fulfil the obligations of the Forest Management Plan.	Throughout project.	Conservation Commission CALM
3	Key Performance Indicators	Develop Key Performance Indicators to target: • water quality and quantity criteria; • safe handling of herbicides; • achievement of retained basal areas; • efficacy of herbicide treatment; • level of damage in retained stems; and • efficacy of burn prescriptions.	Measure project performance.	Concurrent with silvicultural activities in each treatment area.	DoE Conservation Commission CALM FPC Alcoa

#	Topic	Actions	Objectives	Timing	Sources of advice
		• changes in stream invertebrates; • soil protection; • dieback; • changes in indicator fauna species; • changes in understorey; and • consultation and communication.		Within 12-months of start of silvicultural work	
4	Coupe planning	Develop and make publicly available coupe maps and silvicultural prescriptions consistent with CALM's processes and Silvicultural Guidelines.	Describe silvicultural treatments for on-ground activities.	Concurrent with silvicultural activities in each treatment area.	Conservation Commission CALM FPC Alcoa
5	Fire management	• Liaison with CALM to understand their Master Burn Program so project issues impacted by fire can be managed (e.g. timing of dieback mapping). • Support CALM to conduct prescribed burning as required after thinning.	Protect environmental and water values through appropriate fire management.	Throughout the project.	Conservation Commission CALM Alcoa
6	Adaptive management	Prepare an initial adaptive management plan using phased implementation of treatments over 4 to 6 years and best practices that: • mitigate and minimise any potential adverse effects and maximise positive environmental benefit of all proposed treatments by the implementation of best-practice prescriptions; • understand the likely adverse and positive effects on the environment; • monitor the effects of treatments on the specified environmental values and conduct appropriate longer-term research; • communicate findings to a wider public and specific stakeholder groups; and • review and audit results and incorporate the findings and stakeholder feedback into revised best-practice prescriptions (adaptive	• implement other positive environmental practices to achieve additional conservation benefits within the catchment. • uses the precautionary principle; • considers the catchment holistically; • allows adjustment of prescriptions (including ceasing if adverse impacts cannot be ameliorated) based on stakeholder feedback, monitoring and research; and • integrates and describes partnerships, roles, and planning for monitoring, research and communication.	As per project document and Section 3.4	Conservation Commission CALM FPC DoE Serpentine-Jarrahdale Shire Alcoa Academia Public

#	Topic	Actions	Objectives	Timing	Sources of advice
		management).			
7	Improved knowledge	Provide funding to individuals and organisations not connected with the Water Corporation for • appropriate research; • collection of baseline data; • monitoring; and • auditing.	To have independent scrutiny of results.	Throughout the project.	Conservation Commission CALM Academia Consultants
8	Projects for additional environment benefit	Develop and fund ongoing program of environmental improvement projects within the catchment.	Complement longer-term environmental enhancements from silvicultural treatments with shorter-term environmental enhancements.	Throughout the project.	Conservation Commission CALM Serpentine-Jarrahdale Shire Alcoa Academia
9	Research integration	Manage and communicate monitoring and analysis of data, and discipline specific research outcomes, with stakeholders and all researchers.	Facilitate knowledge integration and transfer between researchers.	Throughout the project.	CALM DoE Alcoa Academia
10	Consultation	Involve the community through methods including: • annual public reporting which includes research outcomes; • four yearly reviews; • web-site; • newsletters; • continuation of policy reference group; • continuation of technical reference group; • field trips; and • presentations.	Consult openly with community and partner with stakeholders.	Throughout the project.	Conservation Commission CALM FPC DoE Serpentine-Jarrahdale Shire Alcoa Academia Public
11	Auditing	Regular auditing to be undertaken by: • Water Corporation on the implementation of procedures in the field; • contractors (CALM, FPC and others) on the work undertaken for their contract with the Water Corporation; and • an independent third party	To have independent scrutiny of project impacts and outcomes.	Throughout the project.	Conservation Commission CALM FPC

#	Topic	Actions	Objectives	Timing	Sources of advice
		(the Conservation Commission), to be funded by the Water Corporation and results to be made public.			
12	Locate flora	Undertake further targeted field searches for rare and priority species.	Ensure locations of rare and priority species within the treatment area are known.	Concurrent with silvicultural activities in each treatment area.	Conservation Commission CALM Serpentine-Jarrahdale Shire Alcoa Academia
13	Monitor flora	Monitor specific rare and priority flora species.	Ensure that thinning operations do not adversely impact rare and priority species.	Concurrent with silvicultural activities in each treatment area.	Conservation Commission CALM Serpentine-Jarrahdale Shire Alcoa Academia
14	Protect site vegetation types of high biodiversity value	Monitor the flora in Yarragil 2 and Swamp vegetation complexes.	Ensure that thinning operations do not adversely impact site-vegetation types of high biodiversity value.	Concurrent with silvicultural activities in each treatment area.	Conservation Commission CALM Serpentine-Jarrahdale Shire Alcoa Academia

#	Topic	Actions	Objectives	Timing	Sources of advice
15	Dieback	Ensure that dieback hygiene practices are implemented in all operations and comply with CALM's Dieback Guidelines. Such as: • off-road access for machinery in dieback free areas restricted to dry-soil conditions; • bauxite pits and areas planted to exotics treated as 'uninterpretable' and appropriate cleardown required; • hygiene used to minimise risk of introduction into unaffected stands; • retained basal areas in jarrah stands above 15 m²/ha; • thinning preferred on site-vegetation types where <i>Phytophthora cinnamomi</i> is less favoured; and • manage sites (if any) affected by <i>Armillaria luteobubalina</i>.	Minimise risk of dieback spread.	Throughout the project.	Conservation Commission CALM FPC
16	Understorey	Manage 'wheat-field' regeneration in keeping with natural conditions. Not to favour retention of jarrah or marri in native regrowth forest during thinning.	Retain key understorey species and not change the existing native species mix.	Throughout the project.	Conservation Commission CALM Serpentine-Jarrahdale Shire Alcoa Academia
17	Monitor fauna	Targeted searching and monitoring of key fauna species in the Wungong Catchment.	Understand diversity of fauna in catchment to understand impacts of treatments on fauna.	Throughout the project.	Conservation Commission CALM Serpentine-Jarrahdale Shire Alcoa Academia
18	Protect fauna	Identification and provision of fauna enhancement measures such as: • nesting boxes; • retention of habitat trees and logs; • key midstorey species; and • increased frequency of fox baiting.	No adverse impact on rare, threatened and vulnerable fauna and species protected under JAMBA–CAMBA.	Concurrent with silvicultural activities in each treatment area.	Conservation Commission CALM Serpentine-Jarrahdale Shire Alcoa Academia

#	Topic	Actions	Objectives	Timing	Sources of advice
19	Wetlands (rivers)	To maintain the integrity, ecological functions, environmental values and supply to downstream users of rivers.	Rivers and streams protected through the implementation of the informal reserve system.	Throughout the project.	Conservation Commission CALM DoE
20	Water quantity	Improve the quantity of water in streams (relative to rainfall) through the implementation of this project.	To maintain the quantity of water to existing and potential environmental and social values in the expected drying climate, including ecosystem maintenance and the water resource for the community.	Throughout the project.	Conservation Commission CALM FPC DoE Alcoa
21	Water quality	Works undertaken in accordance with best-practice silvicultural prescriptions. Monitoring and management of the exposed soil of the steep slopes adjacent to Wungong Reservoir. Ensure the use of lowest drinking water quality risk option for thinning (glyphosate is currently used in notching or cut-stump operation).	Maintain water quality of Wungong Reservoir. No long-term increase in stream salinity. No long-term increase in turbidity in streams.	Throughout the project.	Conservation Commission CALM DoE
22	Prevent erosion	Operations, including road construction, will be conducted in accordance with the Soil and Water Conservation Guidelines being developed under the Forest Management Plan, and the interim guidelines until the guidelines are in place. The guidelines have been developed for use in undamaged soil and may need modification for application in areas that have been mined and rehabilitated. No major road construction to be undertaken. However some fire access tracks will need to be opened or maintained. Implement informal reserve system to provide buffers beside streams.	To prevent significant erosion.	Throughout the project.	
23	Conservation areas	Protection of areas as detailed in the Forest Management Plan (formal and informal reserves), as well as areas protected for water	To protect the environmental values of areas identified as having significant environmental	Throughout the project.	Conservation Commission CALM DoE

#	Topic	Actions	Objectives	Timing	Sources of advice
		quality issues (100 m buffer around reservoir) and experimental control purposes (Waterfall Gully sub-catchment).	attributes.		Alcoa Academia
24	Risk	Follow best-practice forest management including: • ensuring staff are trained and follow public safety procedures (such as signage around work areas); • consult with local community about operations; and • design silvicultural treatments to minimise fire risk (such as using cut-stump thinning rather than stem-injection near burn boundaries).	Ensure risk to surrounding community is as low as reasonably achievable and complies with acceptable standards and EPA criteria.	Throughout the project.	Conservation Commission CALM FPC Serpentine-Jarrahdale Shire Public
25	Visual amenity	Thin dense stands by no more than 50% in each stage. Ensure that forest adjacent to travel routes, walk trails and picnic areas is treated using the cut-stump thinning technique or are not thinned.	To maintain the visual amenity.	Throughout the project.	Conservation Commission CALM Serpentine-Jarrahdale Shire Public
26	Recreation	Investigate feasibility within the catchment of: • signage on walk trails; • guided tours; and • track work.	Manage recreation in the Wungong Catchment.	Throughout the project.	Conservation Commission CALM Serpentine-Jarrahdale Shire Public
27	Economics	Provision of a low-cost, safe 4–6 GL water source through the implementation of this project.	Fulfil the state water strategy commitments of a catchment management trial.	Throughout the project.	

4 Conclusions

- This was a useful exercise for the Water Corporation, key stakeholders and the general community. The level of engagement was encouraging.
- Additional ongoing contacts were established.
- Some responses were positive, but more were negative. A high proportion of responses liked parts of the project.
- Most concern was with thinning the native forest, but treatments in rehabilitated areas was favoured.
- Some of those opposed to the project, commented favourably on the quality of the research, the documentation and the consultation process.
- Most issues raised had already been covered in the project document, but more detail was required for some. Some of these questions have helped clarify research directions.
- The review identified a strong preference to thin native regrowth forest to a species mix which maintains the existing proportion of jarrah and marri, rather than the original project plan of favouring marri. The approach of not favouring a particular species will be adopted.
- No fatal flaws were found.

5 Appendix 1 – public review of project

5.1 Elements of public review

The elements that made up the public review where

- Project document that described the project and why it should proceed including commitments. One thousand copies were printed and over three hundred were mailed out prior to start of launch of public review to stakeholders (Appendix 2 – stakeholder list for public review), nearly 40 were mailed out during the public review on request and an additional 50 were given to people at open days and presentations.
- Project brochure that is a 6-page summary of project document had 2000 copies printed, and distributed in a similar pattern to the project document.
- Media statement of launch (Appendix 3 – public review media statement).
- Project web-site and online involvement form (Appendix 4 – Project web-site pages).
- Involvement form which asked people how they wanted to be involved in the project and by what methods, as well providing their contact details to the Water Corporation and guidance for making a submission.
- Launch at Wungong Dam by Minister assisting the Minister for Water Resources on 26 April 2005 (Figure 1 and Figure 2).
- Television and print media coverage of launch.
- Print advertising of project and consultation events run in the Sunday Times on 1 May 2005, and early the following week in the Armadale Examiner and Echo Newspaper (Figure 3).
- Public open days at Serpentine-Jarrahdale Shire and City of Armadale on 3 and 4 May 2005 (Figure 4 and Figure 5).
- Public presentations at Alexander Library and Engineers Australia on 6 and 9 May 2005.
- Several presentations to Water Corporation and CALM staff and meetings with stakeholders.
- Submissions from community and stakeholders (Appendix 5 – submission authors)
- Extension to end of public review on request of conservation groups (from 8 June to 22 June 2005).



Figure 1. Media at launch of public review of Wungong project (Photo by Colin Terry)



Figure 2. Minister being interviewed at launch of public review of Wungong project (Photo by Colin Terry)



Wungong Catchment Environment and Water Management project

Public review period open until 8 June 2005

Improved catchment management was one of the activities identified in the State Government's State Water Strategy, which is addressing the critical water shortage in Western Australia brought about by the drying climate and a growing population.

The Wungong Catchment Environment and Water Management project is a 12-year research initiative to be conducted by the Water Corporation that could recover an average of 4 to 6 billion litres (gigallitres) of run-off water annually.

The project would involve the thinning of selected trees in crowded native regrowth forests and forests that have been rehabilitated after mining. It would also include the staged conversion of introduced tree species to native species.

If the community and regulators are comfortable with the environmental and water outcomes of this project, it is planned to apply similar management to other water catchments.

Where can I get more information?

The Water Corporation invites you to attend the following public presentations/open day:

- Open Day - Mundijong Hall in Paterson Road, Mundijong, on 3 May 2005 from 2pm - 7pm.
- Open Day - Armadale Hall Lesser Hall in Jull Street, Armadale, on 4 May 2005 from 2pm - 6.30pm.
- Presentation - Alexander Library Theatre at State Library of Western Australia, Francis Street, Perth on 6 May from 12 noon - 1pm.

Your guide to providing feedback

The Water Corporation welcomes feedback on the project document, which can be viewed at www.watercorporation.com.au/wungong



Wungong Reservoir and catchment.

While general comments about the project can be helpful, we encourage specific suggestions for improving the project.

The Wungong project is consistent with the Conservation Commission of Western Australia's Forest Management Plan 2004-2013. This plan is available on the Department of Conservation and Land Management's website at www.naturebase.net/forest_facts

If you would like a copy of the project document, email Colin Terry at colin.terry@watercorporation.com.au or call (08) 9420 3751.

Please send your feedback by post to: Dr Colin Terry, Infrastructure Planning Branch, Water Corporation, PO Box 100 Leederville WA 6902.

The Water Corporation will respond to your feedback and incorporate it in a report after the public review period. The report is being prepared for the Environmental Protection Authority who will consider it before providing its advice on the project to the Minister for the Environment.



Figure 3. Advertisement in papers to describe project and consultation events



Figure 4. Open day at Serpentine-Jarrahdale Shire 3 May 2005 (Photo by Colin Terry)



Figure 5. Open day at City of Armadale 4 May 2005 (Photo by Colin Terry)

5.2 Involvement forms

With the aim of encouraging involvement in the Wungong project and also to get feedback on the project, the project document was mailed to stakeholder prior to the launch of the public review with an involvement form. The form was also available at open days, presentations, and mailed with copies of the report when it was requested.

Seventy three forms were returned with most people wanting to be regularly updated on the project by e-mail. Others indicated preferences for being mailed updates, using the project web-site, attending presentations and tours, verbal updates and teleconferencing. Only two people stated they did not want to be further involved and several indicated an interest in being involved in aspects of the research.

5.3 Open days and presentations

While the involvement forms were a good way on encouraging and supporting an ongoing relationship with stakeholders, it was the face-to-face communication during the open days and presentations that was most valuable in engaging the people that attended (Table 2).

Table 2. Dates and numbers of people attending public review events

Location	Date	Time	Approximate number of visitors
Serpentine-Jarrahdale Shire Mundijong Hall ¹	3 May 2005	2–7 pm	28
City of Armadale Lesser Hall ¹	4 May 2005	2–6:30 pm	14
Alexander Library Theatre, Perth ^{1,2}	6 May 2005	12–1 pm	15
Engineers Australia, Perth	9 May 2005	12:30–1:30 pm	40

Events were arranged by the Water Corporation and superscripts refer to input from (1) Department of Conservation and Land Management and (2) Conservation Commission of WA.

Open day participants included people from

- Community
- Local media (print and on-line)
- Shire Councillors
- Land Conservation District Committees (LCDC)
- Youth Activity Council and their parents
- Forest Products Commission
- Department of Conservation and Land Management
- Water Corporation

Presentation audiences included people from

- Community
- Murdoch University
- Conservation Commission of WA
- Department of Conservation and Land Management
- Department of Environment
- Water Resources and Hydrology panel of Engineers Australia's Western Australian Division
- Water Corporation

The questions and perceptions raised during the presentations included:

- Local water cycle – with current interception and crown evaporation being quite high and opening canopy with thinning would increase through fall;
- Alternative views that forest in Wungong was not too dense and that project assumed many things;
- Physical process of thinning and what was involved;
- Forest soon after thinning and potential for fire risk;
- Need for understanding of structural differences between old growth and regrowth forests;
- Clarification about future climate change projected rainfall decreases;
- Need for clarity of project success factors, such as key performance indicators;
- What will need to be done to forest in the future and how often will you need to go back;
- What sort of changes are expected to water quality; and
- How does the unit cost of this project as a water source compare to other water sources such as South West Yarragadee and Kwinana desalination.

A common sequence of reactions during the open days and presentations was people were

1. Initially concerned about or at least cautious of the project, and often had the wrong information of what is planned (e.g. they thought incorrectly the silviculture prescription was to clear all the trees in 62% of the catchment – rather than thin to 15–18 m²/ha basal area, which effectively increased the spacing between trees in the treated area from 3–4 m to 5–6 m);
2. Then interested in finding out about what was planned and known about catchment management; and
3. Finally people were more comfortable with the project as a research trial, or if not comforted as they still had uncertainties about whether the project would achieve its objectives, they had a clearer idea about what was going on.

6 Appendix 2 – stakeholder list for public review

State members of Parliament, in particular

- Premier - Minister for Water Resources
- Minister assisting the Minister for Water Resources
- Minister for the Environment

Local government

- Shire of Serpentine-Jarrahdale
- City of Armadale
- Shire of Wandering

Government agencies

- Department of Environment
- Conservation Commission of WA
- Department of Conservation and Land Management
- Forest Products Commission
- Environmental Protection Authority
- Department of Industry and Resources
- Department of Health

Alcoa World Alumina Australia

Research institutions

- Murdoch University
- University of WA
- Curtin University
- Edith Cowan University
- CSIRO

Museum of WA

South-west Aboriginal Land and Sea Council

Conservation groups

- Conservation Council of WA
- EARTH
- Western Australian Forest Alliance

Community interest groups

- Ratepayers associations
- Local conservation groups

Media

- Local
- State

Water Corporation staff

7 Appendix 3 – public review media statement

Government of Western Australia Media Statement



The Hon. John Kobelke MLA

Minister for Consumer and Employment Protection; Indigenous Affairs;
Minister Assisting the Minister for Water Resources

Statement Released: 26-Apr-2005

Portfolio: Assisting in Water Resources

Wungong Catchment research project to boost water run-off

26/04/05

A public review has been launched today for a project that could lead the way to delivering an extra 40 billion litres (gigalitres) of water a year to Perth's reservoirs.

Minister Assisting the Minister for Water Resources John Kobelke announced the public review into the \$20million Wungong Catchment Research Project, to substantially increase run-off and also provide environmental benefits.

"Improved catchment management was one of the activities identified in the Gallop Government's State Water Strategy, which is addressing the critical water shortage in Western Australia brought about by the drying climate," Mr Kobelke said.

"The Gallop Government is protecting and enhancing WA's unique lifestyle and environment and in a dry State like this, the way we manage our water is crucial."

The Minister said the Wungong Catchment Environment and Water Management project was a 12-year research initiative to be conducted by the Water Corporation that could recover an average of four to six billion litres (gigalitres) of run-off water annually, at a cost of about 25 cents per thousand litres.

"If it is as successful as predicted and applied to other catchments serving the metropolitan area, that could give us the potential to tap into as much as 40 billion extra litres each year," Mr Kobelke said.

"The first step, however, is to make sure the community and regulators are comfortable with the environmental and water outcomes of this project in the Wungong Catchment.

"Past research in WA has provided understanding about streamflow increases from catchment thinning, but the environmental benefits of this management activity are yet to be fully tested, so that is why a staged approach starting with Wungong is sensible.

"The project would involve the culling (thinning) of selected trees in crowded native regrowth forests and forests that have been rehabilitated after mining.

"It will also include the re-establishment of native forest, through the replacement of exotic tree plantations and plots - including the bauxite mining rehabilitation areas."

The Wungong Catchment, which does not contain any old growth forest, comprises an area of 12,845ha or about 130sq.km and has been disturbed by many different uses in the past.

Under the proposal, the area for environment and water management would cover about 62 per cent (7,900ha), incorporating about 5,100ha of native forest.

The remaining 38 per cent of the catchment would not be touched, except by CALM's prescribed burning.

Mr Kobelke said there were no simple solutions to the water challenges facing WA, so the Gallop Government was tackling this issue on a number of fronts.

"This research project is particularly attractive as it is low-cost; makes use of existing water sources and infrastructure; and has the potential to deliver environmental benefits," he said.

Forest management activities in the Wungong Catchment Project have been assessed as approximately greenhouse neutral, with a balance between release of carbon from the thinned trees and carbon storage in the remaining trees, which would grow faster.

The project was designed in close consultation with stakeholders to ensure that it would be consistent with the Conservation Commission of Western Australia's Forest Management Plan 2004 - 2013.

WA's Conservation Commission and the Department of Conservation and Land Management (CALM) have agreed the project would be consistent with the Forest Management Plan.

The Water Corporation's proposed project has been presented to the Environmental Protection Authority, which is expected to provide advice after the six-week public review period that will conclude on June 8.

Minister's office: 9222 9211

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8 Appendix 4 – Project web-site pages

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Wungong Catchment Environment and Water Management Project

Summary

Catchment management for the environment and water is important for our water resources and the natural environment.

Perth's catchments are forested with mainly regrowth Jarrah and Mann trees. Their current dense pole-and structure is due mostly to large scale forestry before the 1950s. This structure is likely to remain unchanged for many centuries if left unmanaged. The aim is to help move the forest back towards a mature structure. As a water source, catchment management is low in cost as it uses existing infrastructure. It has been researched at a 60 ha scale during the 1980s and 1990s. Following the water forums during 2002, the 2003 State Water Strategy supported a catchment scale trial.

The Wungong Catchment: will be the location of a 12-year trial of catchment management. It will recover on average 4-6 gigalitres of streamflow annually, depending on rainfall, which is a 25% improvement. This will help mitigate the effect of a drying climate. The project is expected to cost the Water Corporation \$20 million and provide water at approximately \$0.25 per kilolitre. Up to approximately 65% of Wungong Catchment's 12 845 ha will be non-commercially thinned in a staged approach over the initial 4-6 years of the project. Environmentally sensitive areas will be avoided, in line with the requirements of the Forest Management Plan 2004-2013. Thinning will double the spacing between trees in the treated areas to 5-6 metres.

Current situation

Stakeholder consultation for the Wungong Catchment Environment and Water Management project started in May 2002 and has included presentations, field trips and public documents. Feedback from this consultation has helped develop the Wungong project.

In early 2005, the Conservation Commission of Western Australia and Department of Conservation and Land Management agreed the Wungong project is consistent with Conservation Commission's Forest Management Plan 2004-2013. The Water Corporation presented the project to the Environmental Protection Authority (EPA) on 24 February 2005. The EPA agreed to provide Section 12 advice after the Water Corporation's six-week public review period (26 April 2005 to 6 June 2005). The Water Corporation will then prepare a report on the issues raised during the public review for the EPA to consider before finalising its advice. The EPA advice is expected to be available by the end of August 2005. Subject to this advice, on-ground work is expected to start in Spring 2005.

The Water Corporation is keen to involve the community and stakeholders through the 12-year trial in an open and transparent manner. For more information, including the project document, see our project's publications page. Any questions or ideas can be directed via email to Colin Terry or phone (08) 9420 3751.

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Jarrah forest a century ago

Over a century ago before manipulation by Europeans, the Jarrah forest was very different to today's dense pole-and regrowth forest. It was a mature open forest you could ride a horse through.

The images with captions are from S. Dell, J. J. Neale & N. Malpas (eds.) (1985) Jarrah Forest: A Century Ago. The photos show, with captions, patterns of branching. Quanta like these represent the full development of the species - the natural selection to which every jarrah is genetically programmed to aspire.

James (Mancoske redwood) and low shrubs are visible, and three small trees, at left, probably a eucalyptus (Eucalyptus elliptica), at right, sheath with the pale bark (see no. 35) and tall Jarrah (Eucalyptus grandis). Both Jarrah. Clearly the dominant trees here appropriate most of the available light and nutrients.

Jarrah forest with fallers at work: 1920

A right-handed faller would work together with a left-handed faller when possible, otherwise alone. Here we see one such pair. Felling a large tree (like the one at right) took five or six men about a mile and an hour or so.

Source: Government Printing Office 44266
 Select to enlarge

Forest scene: Jarrahdale

"The forests of this tree have been thoroughly representative, and have, during the last twenty years, produced a large quantity of timber for Melbourne and Foreign Markets. - (Browne 1895)."

Source: Government Printing Office 44266
 Select to enlarge

Jarrah forest along Karidale Road: 1914

"Hills, 4 and 5 are both of Jarrah and both fairly near Margaret River, yet in this one the Jarrah are typical forest trees - tall and long-barked whereas in no. 5 they spread out and hardly overlap the buttresses. This difference in structure probably reflects a difference in soil."

The tree at far left is a man; note the last strips bark and the dark blum caused by felling gum.

To the modern eye, this thick forest and winding line look more impenetrable than real."

Source: Government Printing Office 44266
 Select to enlarge

Reference:
 S. Dell, J. J. Neale & N. Malpas (eds.) (1985). The Jarrah Forest - A Century Ago. Western Australian Government, Department of Conservation and Land Management.

Robert Powell and Jane Emberson (1979). An Old Look at Trees: Vegetation of South-Western Australia in Old Photographs. Publisher: Campaign to Save Native Forests (in A.C.S. Environment Centre, 194 West St, Perth, WA, 6000)

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Wungong Catchment Environment and Water Management Project

The Wungong project is expected to run for 12 years and there are several ways for you to be involved. This form is for you to tell the Water Corporation how you would like to be involved and for you to provide us your contact details.

The Wungong Catchment Environment and Water Management Project is now open for public review and you are invited to make a comment on the project document. The review closes on 8 June 2005.

1. Which way(s) will you be involved?

(You can tick more than one)

☐ a) I'll be informed of progress regularly

☐ b) Help with on-ground activities as volunteer (specify your area of interest): _____

☐ c) Help with research (specify your area of interest): _____

☐ d) Other: _____

2. What is your priority for our method of communication with you?

("1" for most preferred, "2" for second preference, etc., and "N" for not to be used?)

☐ a) Self serve from project website

☐ b) E-mail newsletter

☐ c) Posted hardcopy version of newsletter

☐ d) Attend presentations or workshops

☐ e) Attend tours or field trips

☐ f) Other: _____

3. Can you please provide your name and contact details:

Title:

First name:

Last name:

E-mail address:

Postal address:

Suburb/Town:

Postcode:

Phone number:

Affiliation:

(e.g. member of community, or belong to an organisation)

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Wungong Catchment Environment and Water Management Project

Wungong project publications

Project brochure

A six page summary of the project (1.1 MB)

Project document

Full project description, which can be viewed as:

- Whole document (10 MB)

or in parts

- Front cover
- Executive Summary and contents page
- 1 - Introduction
- 2 - Community consultation
- 3 - Development of the project
- 4 - Overview of existing environment
- 5 - Project description
- 6 - Potential negative impacts and strategies to minimise them
- 7 - Potential positive effects
- 8 - Conclusions
- 9 - Contributors
- 10 - Glossary
- 11 - Selected bibliography
- Appendix 1 - Objectives and commitments
- Appendix 2 - Forests compared
- Appendix 3 - 27 September 2002 field trip
- Appendix 4 - Summary of Forest Management Plan (FMP)
- Appendix 5 - Summary of Informal Reviews
- Appendix 6 - Jarrahdale water quality risk assessment
- Back cover

You will need Adobe Acrobat Reader to view these PDF documents.

[Click here to get it free](#)

Your guide to providing feedback on the Wungong project

The Water Corporation welcomes feedback on the project document. To help us collate your feedback with that from others, it would be helpful if you could reference the section or page number in the project document you are responding to, while general comments about the project can be helpful, we would encourage specific suggestions for improving the project and for emphasising those areas that are important to you.

The Wungong project is consistent with the Conservation Commission of Western Australia's Forest Management Plan 2004-2013. This plan is available on the Department of Conservation and Land Management's website at: [www.dcl.wa.gov.au/forest/mfpm2003](#)

The Wungong project document, plus future reports and information bulletins can be found on this project web-site. If you would like a printed version of the project document, please contact Colin Terry by e-mail or mail (see details below), or by phone (08) 9420 3751 or fax (08) 9420 3179.

Please e-mail your feedback to com@watercorporation.com.au or post to:

Dr Colin Terry
 Infrastructure Planning Branch
 Water Corporation
 PO Box 120
 Leederville WA 6902

We will respond to your feedback and incorporate it in a report to be prepared after the period of public review closing on 8 June 2005. The report will be made available on the project's web-site. The report is being prepared for the Environmental Protection Authority (EPA) who will consider it before providing their advice on the project to the Minister for the Environment. The EPA advice is expected to be available by the end of August 2005.

Pages:

- Terry, C.T., Bath, R.E., and Field, A.J. (2004) A Case for adaptive management in the Wungong Catchment: A Forest Consciousness Conference Proceedings 6th National Conference of the Australian Forest History Society Inc., 12-17 September 2004, Augusta, WA, Western Australia, Netherlands

9 Appendix 5 – submission authors

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Dr Paul Van Buynder	Department of Health
Mr Rob Versluis	Western Australian Forest Alliance
Miss M Watson	
Prof Philip Weinstein	UWA School of Population Health
Mr David Wettenhall	Institute of Foresters of Australia, WA Division
S. Williams	
petition with 59 people against project	unknown

Wungong Catchment Environment and Water Management Project

